MADYMO FOLDER

FOLDING AIRBAG MODELS

Version 4.0 (Madymo 6.x), June 2006

Oasys Limited
13 Fitzroy Street
London
W1P 6BQ

Preamble

Development status

This manual documents the fifth release of FOLDER (4.0)

Memory requirements

Memory is allocated dynamically, so the amount required rises in proportion to the amount of data being manipulated. A suggested minimum amount of memory is 32MBytes, which should accommodate models of up to about 150,000 nodes & elements without requiring virtual memory. Memory usage will rise linearly with model size, so this figure may be extrapolated for larger models.

Output devices

The code supports the following graphical devices:

- X_Windows Colour, greyscale & monochrome
- Open GL 3-D generic graphics - this is the recommended choice on all computer platforms.
- Postscript (Adobe 2.0) Laser driver.
- Windows bitmap files
- JPEG files

Revision history

Revision	**Date**	**Description**
Rev 0	April 1999	Initial release of version 1.0 software
Rev 1	March 2001	Release 2.0
Rev 2	October 2001	Release 2.1
Rev 3	March 2003	Release 3.0
Rev 4	May 2006	Release 4.0

Text conventions used in this manual

Typefaces

Three different typefaces are used in this manual:

Manual text	This typeface is used for text in this manual.
Computer type	This one is used to show what the computer types. It is also used for equations, keywords (eg ***PART**) etc.
Operator type	This one is used to show what you must type.
Button text	This one is used for screen menu buttons (eg **APPLY**)

Notation

Triangular, round and square brackets have been used as follows:

Triangular To show generic items, and special keys. For example:

```
<list of integers> <filename> <data component>
```

```
<return> <control Z> <escape>
```

Round To show optional items during input, for example:

```
<command> (<optional command>) (<optional number>)
```

And also to show defaults when the computer prompts you, eg:

```
Give new value (10) :
```

```
Give model number (12) :
```

Square To show advisory information at computer prompts, eg

```
Give filename: [.key] :
```

```
FOLDER_MANAGER >>> [H for Help] :
```

Also to show implicit commands, eg

```
[ORIENT] TRANSLATE <entity> <number of values>
```

1 Running FOLDER

1.1 Starting the code

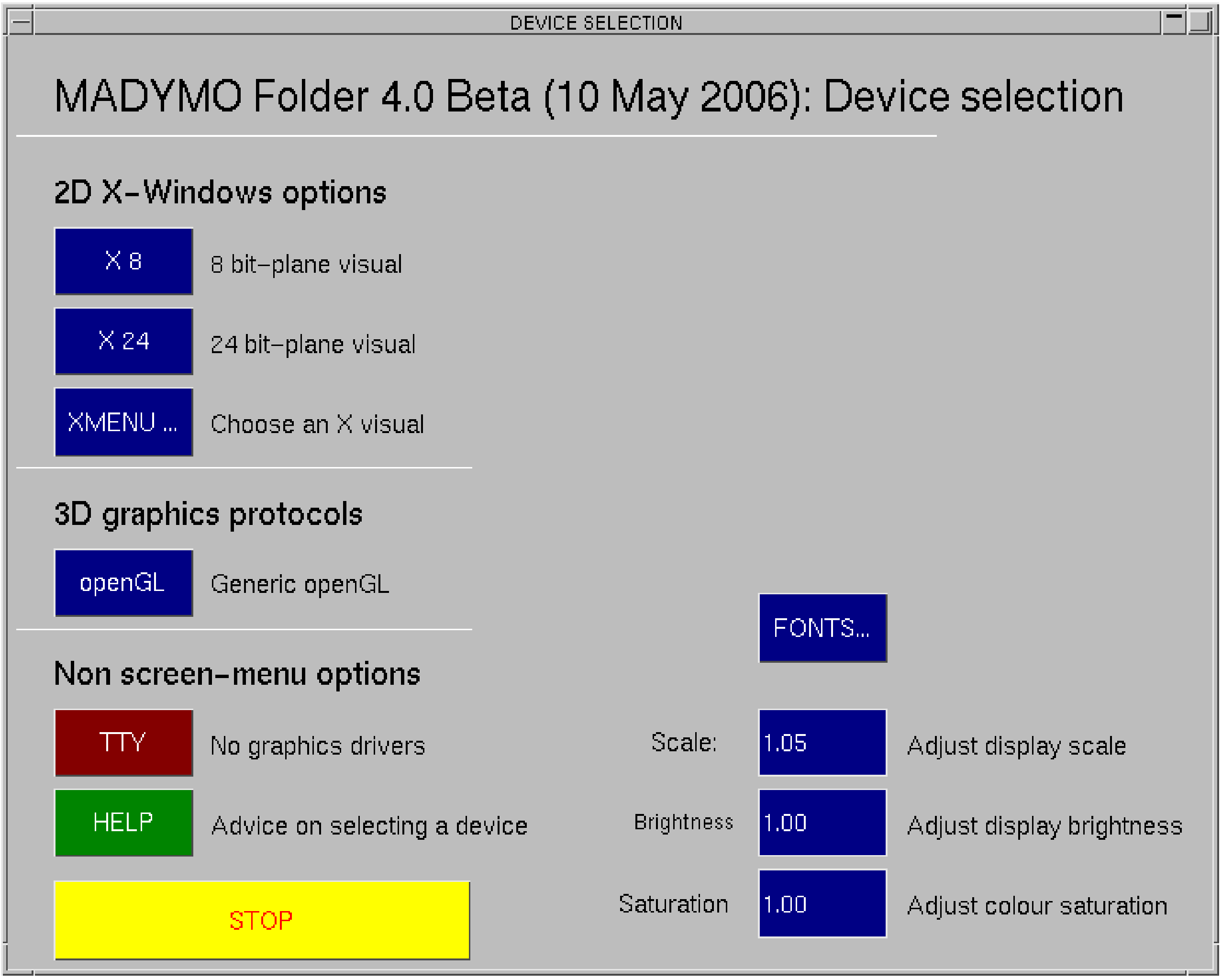
FOLDER is run from the command line.

FOLDER may be run both locally on your machine and remotely, in client/server mode, using the remote machine (client) to display on the local screen (server). For remote usage it will be necessary to set the host's **`DISPLAY`** environment variable to point to the server, and to enable remote display on the server: see section 1.3 if you have problems doing this.

1.2 Selecting a graphics device

On Windows This panel is not normally mapped, and FOLDER starts under OpenGL automatically

On Unix / Linux When FOLDER starts you will see the device selection panel:



Scale: 1.05

Brightness 1.00

Saturation 1.00

The actual devices available will depend on your machine type and the graphics options that have been installed. Most workstations will provide both X11 and OpenGL graphics, but older machines may have a more limited range of options.

OpenGL Selects the 3D OpenGL device, using hardware acceleration if available. This is the best choice of all if it is available on your system.

X8 Selects an X11 visual with 8 bit-planes. Shading will be limited, as only 256 colours will be available

X24 Selects an X11 visual with 24 bit-planes. Over 16 million colours will be available, so shading will be better - this is the recommended choice under X-Windows.

XMENU Lets you choose from all the visuals available on your system. Use only if one of the standard options doesn't work - you may need to ask Oasys for advice.

Note: If you always want to start FOLDER with the same graphics device you can do so by defining a "`-d=<device>`" command-line argument. This will bypass the device selection panel above. See Command Line Arguments below for more details.

The other command options on this panel are:

FONTS Allows you to choose font typefaces, style and size. (May also be set interactively from the Options >, Menu Attributes pulldown window.)

TTY Invokes text-only mode with no graphics or menus

HELP Gives online advice about using this panel

STOP Stops the FOLDER session.

There are also three settings that control the appearance of the screen menu interface (but not the graphical images of your model). These are:

Scale Controls the effective scale of the display used for the menu interface.

The menu system for FOLDER was designed for a high resolution (1280 x 1024) display of at least 17" size. On smaller screens and/or lower resolution displays it can be a bit over-sized leading to some panels being too small for their contents. The "scale" value can be used to factor the physical size of the display: values greater than 1.0 will make it appear to be larger, so text and buttons will shrink making more of them fit into panels.

This variable may also be set using the environment variable **DISPLAY_FACTOR**. Valid settings being a number in the range 0.5 to 2.0, or the word "automatic". For example:

`setenv DISPLAY_FACTOR 1.2` (C shell syntax)

`DISPLAY_FACTOR=automatic; export DISPLAY_FACTOR` (Bourne shell)

The "automatic" setting calculates a factor based on your physical screen size: you can still overwrite it in this front panel.

(May also be set interactively from the Options >, Menu Attributes pulldown window.)

Brightness Controls screen menu colour brightness.

On some displays the colours in the screen menu come out garishly bright. This value may be set in the range 0.0 to 1.0 to control this brightness: 1.0 being light, 0.0 being dark. It too may be set as above with the environment variable **DISPLAY_BRIGHTNESS**.

Saturation Controls screen menu colour saturation.

As with brightness the colour saturation of the screen menu may be set in the range 0.0 to 1.0 (totally grey to fully saturated colours). Again there is an environment variable **DISPLAY_SATURATION** which may be used to set this globally as described above.

You may need to experiment a bit to find the right values for your particular display but, once found, the environment variables are probably the best way to set them. There is the additional advantage that they will also apply to Oasys T/HIS and D3PLOT.

NOTE: From FOLDER version 4.0 onwards the Display Factor, Font attributes, and left-handedness may be set interactively using the Options >, Menu Attributes pulldown menu

A complete listing of all possible command line arguments and environment variables may be found in Appendix IV

1.3 If FOLDER will not start on your display

On a system running an X11 based window manager, generally Unix, this is almost certainly because of one or both of the following setup errors:

- The DISPLAY environment variable has not been set up, or has been set incorrectly. This tells the X11 window manager where to place windows, and it must be set to point to the server's screen. Its generic setup string is:

  `setenv DISPLAY <hostname>:<display number>` (C shell syntax)

  Where <hostname> is the server's name or internet address, for example:

  `setenv DISPLAY :0` (Default display :0 on this machine)

  `setenv DISPLAY tigger:0` (Default display :0 on machine "tigger")

  `setenv DISPLAY 69.177.15.2:0` (Default display :0, address 69.177.15.2)

  You may have to use the raw network address if the machine name has not been added to your **`/etc/hosts`** file, or possibly the "yellow pages" server hosts file.
- Your machine (strictly the X11 "server") has not been told to accept window manager requests from remote machines. This is usually the case when you are trying to display from a remote machine over a network, and you get the message similar to:

  ```
  Xlib: connection to "<hostname>" refused by server

  Xlib: Client is not authorised to connect to server
  ```

  In this case go to a window with a Unix prompt on your machine, and type:

  ```
  xhost +
  ```

  Which tells your window manager to accept requests from any remote client. It will produce a confirmatory message, which will be something like:

  ```
  access control disabled, clients can connect from any host
  ```

A full explanation of networked graphics is too complex a topic for this manual: if the simple remedies here don't work see your system manager, or contact TASS for advice and help.

1.4 Command Line arguments.

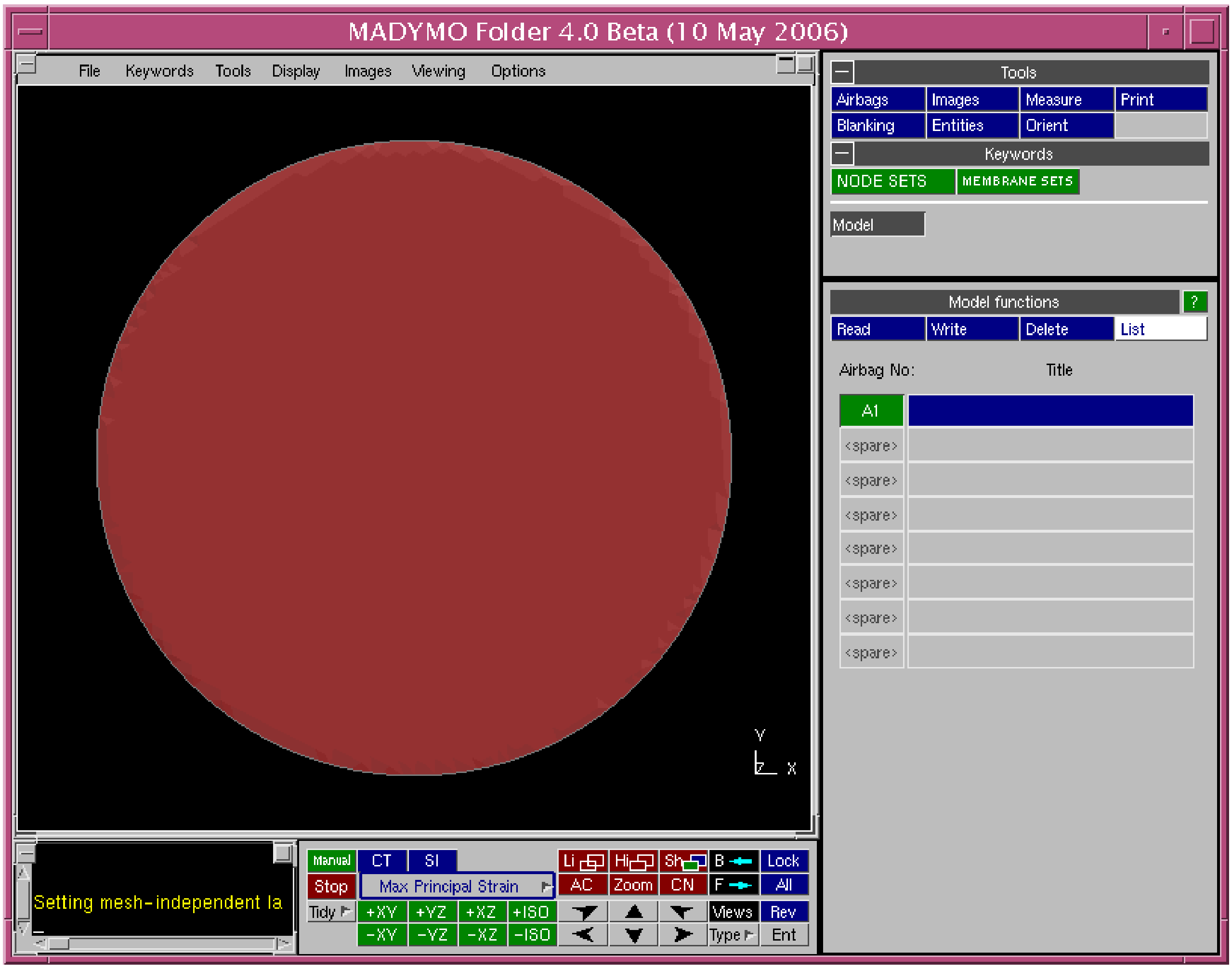
FOLDER has a range of arguments that can be added to the command line. These are:

<table>
<tr><th>Function</th><th>Format</th><th colspan="2">Options</th></tr>
<tr><td rowspan="5"><b>Setting the graphics device</b>
By default no graphics device is defined, and the device selection panel is mapped.
These options can be especially useful if you want to bypass the device selection panel and always start FOLDER with a particular graphics driver.</td><td rowspan="5"><code>-d=<i>&lt;device&gt;</i></code></td><td><code>-d=opengl</code></td><td>Use OpenGL 3D graphics</td></tr>
<tr><td><code>-d=x24</code></td><td>24 bit-plane X-Windows graphics</td></tr>
<tr><td><code>-d=x8</code></td><td>8 bit-plane X-Windows graphics</td></tr>
<tr><td><code>-d=x</code></td><td>X24 if available, otherwise X8</td></tr>
<tr><td><code>-d=default</code></td><td>Whichever is available in the order OpenGL, X24, X8</td></tr>
<tr><td><b>Specifying "full screen" mode on startup</b>
Normally FOLDER occupies about 70% of the display when it starts, the "maximise" argument changes this to become the full screen.</td><td><code>-maximise</code></td><td colspan="2"></td></tr>
</table>

2 Using Screen Menus

2.1 Basic screen menu layout

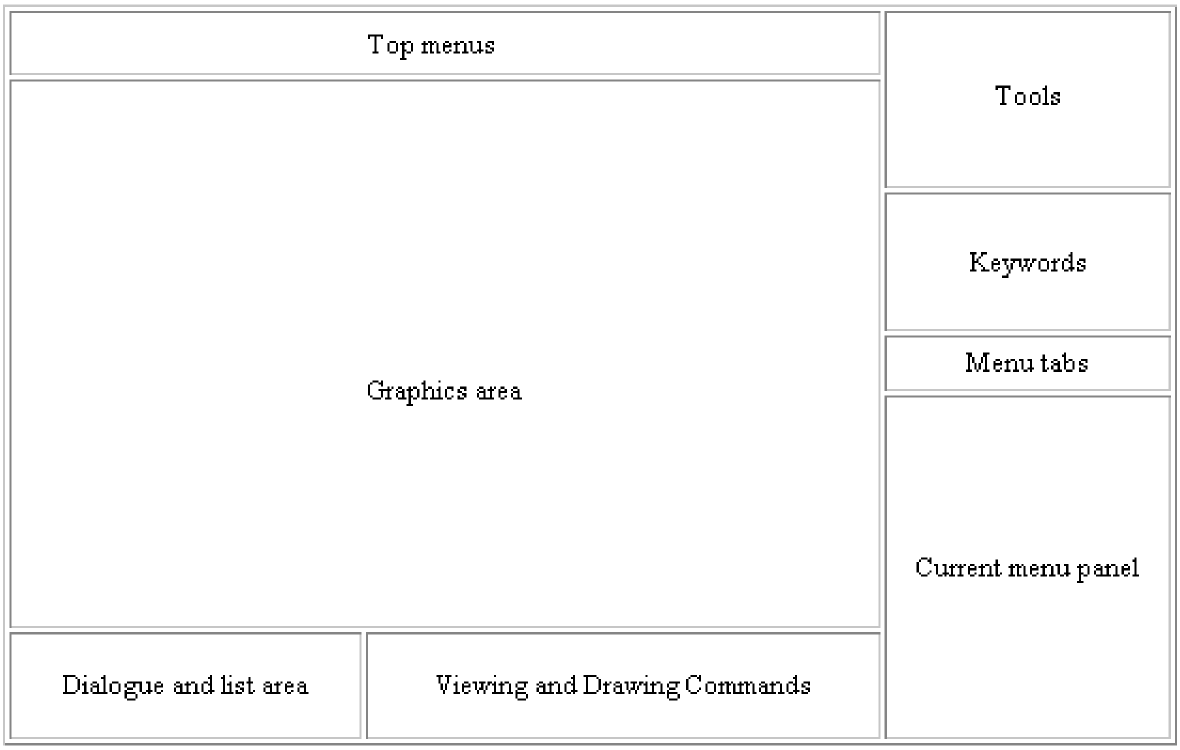
FOLDER runs within a single window, owned by the window manager, which has several sub-windows inside it. A typical FOLDER session will look like this:



Setting mesh-independent la

The various sub-windows always exist within the master window, and may be moved and resized at will inside it. They will keep their relative size and position as the master window is changed in size and/or shape, and will reappear after the main window is de-iconised.

The default layout of the main sub-windows is as follows:



These windows cannot be dismissed. A brief description of their functions is:

- "Top menus" This is included in the same window as the Graphics area. It allows access to some of the basic options.
- "Graphics area" Is where graphics are drawn.
- "Tools" This menu provides access to many different functions available in FOLDER.
- "Keywords"This provides access to all the Keywords supported by FOLDER.
- "Menu Tabs" These control which option is displayed in the current menu panel. Model will always be available in addition to selected options.
- "Current Menu Panel" Displays the menu for the option currently selected by the menu tabs.
- "Dialogue & list" Allows "command-line" input and output, also provides a listing area for messages.
- "Viewing and Drawing Commands" provides all aspects of view control: direction, perspective, scale, etc and

contains the drawing commands and their settings.

While you are free to re-position these master windows it is recommended that you keep to this default layout. This is because when further sub-windows appear their position and size is designed assuming this layout, and aims to obscure as little useful information as possible. The TIDY command in the "Viewing and Drawing" box will restore the screen layout to this default state.

2.2 Mouse and keyboard usage for screen-menu interface

Most screen-menu operations are driven with the left mouse button only, but there are exceptions:

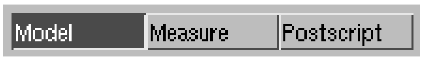
- "Popup" menus are invoked with the right mouse button; those in the Top menus, Tools and Keywords areas can also be invoked with the left mouse button.
- Text in the dialogue area and text boxes requires keyboard entry;
- Text strings saved in the cursor "cut" buffer may be "pasted" into dialogue areas and text boxes using the middle mouse button.
- Dynamic viewing (<meta key> + <mouse button>) uses the three mouse buttons to distinguish different modes. Section 9 describes viewing.
- Some specialist functions use different mouse buttons for particular functions.

- Screen-picking uses:
  Left button to select;
  Middle button to reject most recent selection
  Right button to reject what is under the cursor.

2.2.1 Buttons

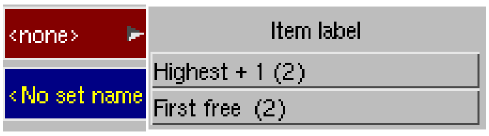
Screen buttons are depressed by clicking on them, but action only takes place when the mouse button is released, so it is safe to drag the (depressed) mouse around the screen.

Buttons may be set (ie depressed) by FOLDER itself, for example the "**MODEL**" one above, to indicate that this option is in force. They may also be greyed out, to indicate that the option is not currently available. Some buttons repeat automatically when held depressed: this depends on context. Buttons with "..." after them will invoke sub-menus.



The primitive "widgets" in the menu interface are used as follows:

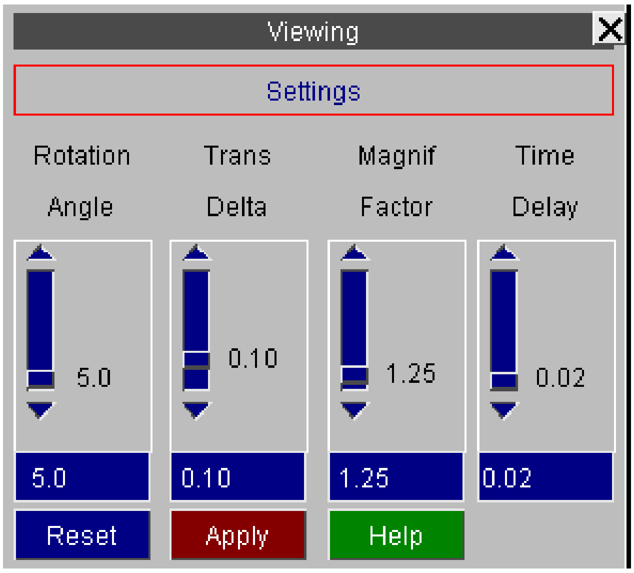
"Popup" window invocation: Buttons with an ">" symbol may be selected normally with the left mouse button, but if the *right* mouse button is depressed over them it will invoke a "popup" window. Move the cursor into this window to make a selection, or move elsewhere and click a button to deactivate the popup.



2.2.2 Sliders

Sliders are moved by clicking on the slider button itself and then dragging it to a new position.

They may also be moved automatically by clicking on, and holding down, one of the arrows at either end. Using the left mouse button for this advances the slider by 1 unit, the middle button by 10, and the right button by 100.



Rotation Angle 5.0

Trans Delta 0.10

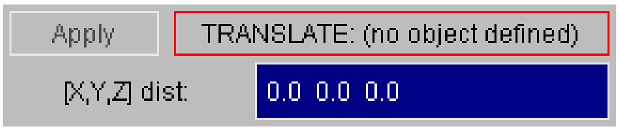
Magnif Factor 1.25

Time Delay 0.02

2.2.3 Text boxes

To enter text in a text box: first make it "live" by clicking on it, then type in text, then type `<return>` to enter the string. Clicking on a "live" box for a second time is exactly the same as typing `<return>`, so clicking twice on a box effectively enters its current contents. You can use the left and right arrow keys for line editing within a box: text entry takes place after the current cursor position. Control U (^U) will delete the entire text box contents.

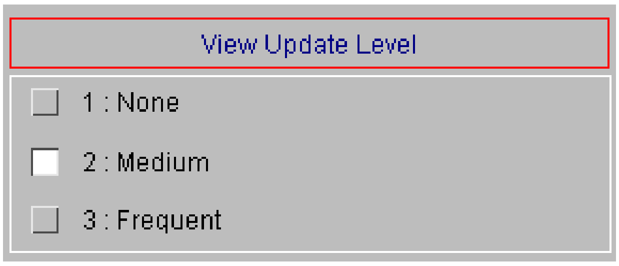
You can "drop" the current X-Windows cut/paste buffer contents into a text box with the middle mouse button, just as you would in a shell (terminal) window.



[X,Y,Z] dist: 0.0 0.0 0.0

2.2.4 Radio boxes

A "radio" set is provided where only one selection is possible from a range of options. In this example the view "update" frequency has been set to level 2. To select click anywhere on the row of the relevant option, any previously selected item will be deselected.



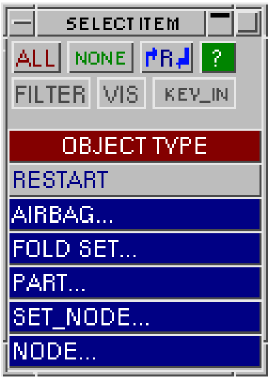
☐ 1 : None

☑ 2 : Medium

☐ 3 : Frequent

2.2.5 Menu selections

Menus of items are used when you need to make one or more selections from a (potentially) long list. Click on the row you want to select: clicking on a row that is already selected will have the effect of deselecting it.



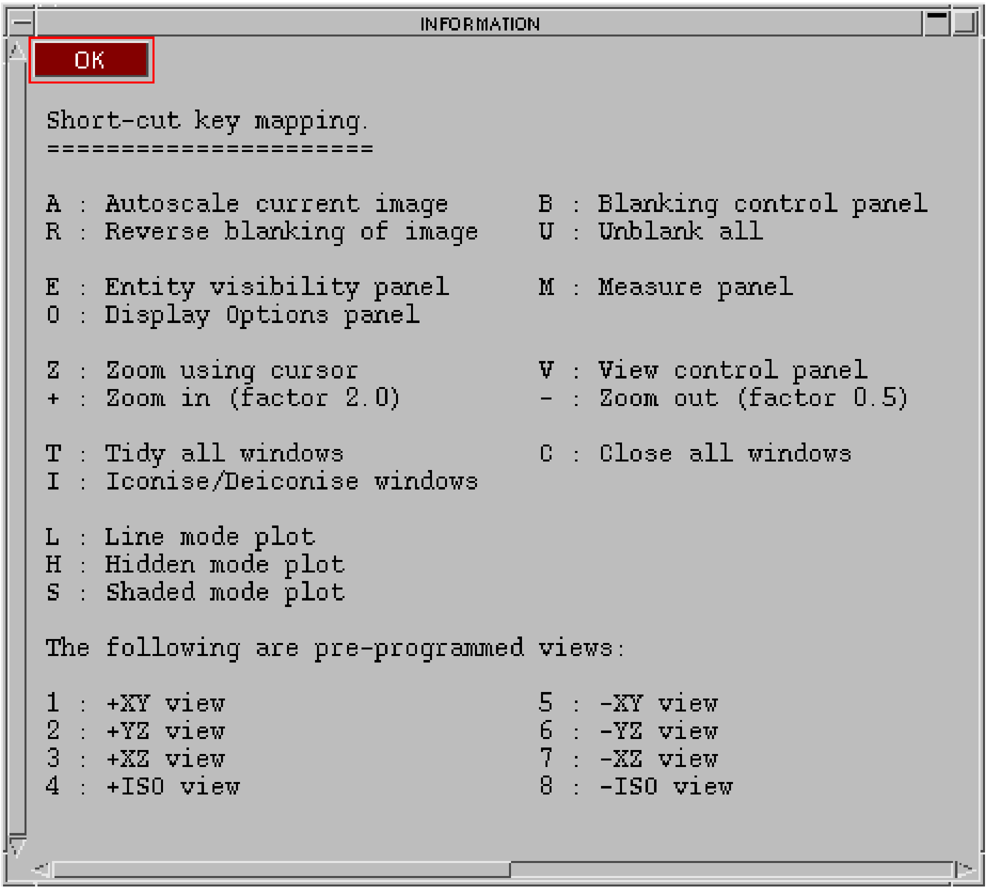
Where selecting more than 1 item would be valid you can "drag" (click, hold down and move) down the menu to select multiple items. Alternatively the <click> (start of range) .. <shift><click> (end of range) method (cf Windows) may be used.

When the list is too long to display in the window you can use the vertical scroll-bars to move up and down it. The filter button allows a subset of the selected entities to be offered, e.g. only those parts of a particular material type. See section 6.0.2 for more information on filtering. The menus are refreshed automatically after creation, editing or deletion of data; alternatively the [R] button can be used to refresh the button.

By default menus will expand horizontally when you move the mouse into them in order to show more of their contents.

2.2.6 Shortcut keys

Certain functions can be accessed by pressing a key on the keyboard. Below is a list of the keys and their effects:



```
Short-cut key mapping.
======================

A : Autoscale current image      B : Blanking control panel
R : Reverse blanking of image    U : Unblank all

E : Entity visibility panel      M : Measure panel
O : Display Options panel

Z : Zoom using cursor            V : View control panel
+ : Zoom in (factor 2.0)         - : Zoom out (factor 0.5)

T : Tidy all windows             C : Close all windows
I : Iconise/Deiconise windows

L : Line mode plot
H : Hidden mode plot
S : Shaded mode plot

The following are pre-programmed views:

1 : +XY view                     5 : -XY view
2 : +YZ view                     6 : -YZ view
3 : +XZ view                     7 : -XZ view
4 : +ISO view                    8 : -ISO view
```

Shortcut keys are effective when the mouse is in any FOLDER window ***except*** the dialogue box, in the latter they are interpreted as normal text input to the command-line interpreter.

2.3 Dialogue in the screen menu interface

The dialogue box is used for listing messages, warnings and errors to the screen. It can be scrolled back and forth (its buffer is 200 lines long) to review earlier messages. The following colours are used:

- Normal messages and prompts Yellow
- Warning messages and Error messages Red

2.4 Window management in the screen interface

Menus in FOLDER are either "docked" (appear in a fixed size and position in the Current Menu Panel) or "floating" (can be moved and resized).

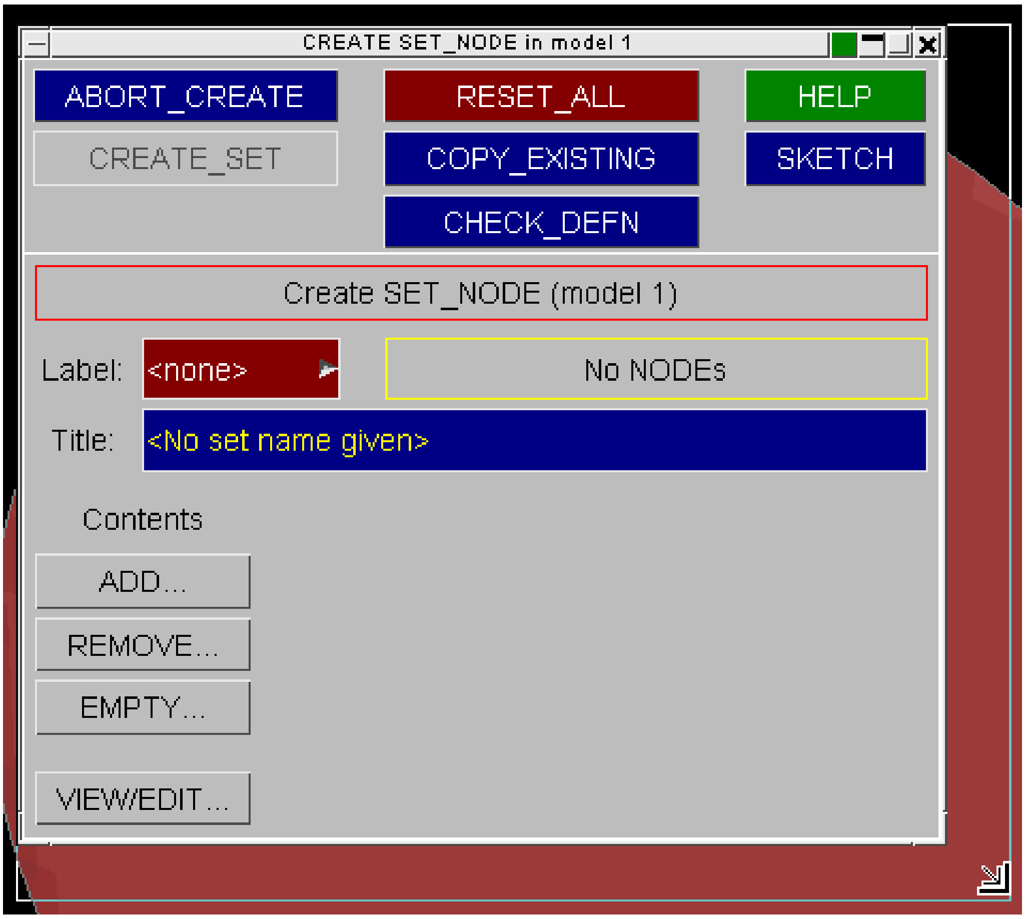
Moving, resizing and scrolling of windows is based on the conventions used in the Motif Window Manager.

To move a window (floating menus only): Click down on its title bar, then drag the window to where you want it to be. A "rubber-band" outline moves to show the window's current position.

To resize a window (floating menus only): Click on a border bar to move just that side, or on a corner bar to move both sides attached to that corner. Again, a rubber-band outline shows you the new shape. You can maximise a window using the square button at its top right, and iconise it using the minimise button next to this.

To scroll a window: If a window has become too small for its contents then horizontal and/or vertical scrollbars will appear. Click on a scrollbar slider and move it to the desired position, the window contents will scroll as you do so. Alternatively click on the arrows at either end of the scrollbar for timed motion in that direction.

This example shows a sub-window being resized:



Label: <none>

No NODEs

Title: <No set name given>

The user has chosen to drag the bottom right corner out.

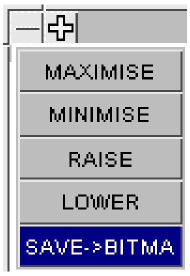
The "title bar" is the area where, in this example, it shows the name of the sub-window:

CREATE SET_NODE in model 1

To dismiss a window, Either press **DISMISS**, or click the x in the top-right of the window or press ESC on the keyboard.

2.4.1 Popup menus for window management:

Clicking on the [-] button at the top left of a window invokes the popup menu for window management:



MAXIMISE expands the window to its full size (in the case of the dialogue and graphic areas this is taken as the entire FOLDER window, for other sub-windows the minimum size such that no scroll bars are required).

MINIMISE collapses the window to a bar. This will be positioned where the top right -hand corner of the window was.

If a window has already been maximised the option to do so will be replaced by **RESTORE** or if minimised by **EXPAND**. These will undo the effect of maximisation and minimisation respectively.

RAISE raises the window to the front of the "stacking order", obscuring any others.

LOWER lowers the window to the bottom of the stacking order, allowing other to obscure it.

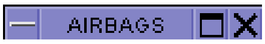
SAVE->BITMAP saves this window (and its borders) as a "bitmap" (.bmp) file.

2.4.2 Use of Menu Tabs

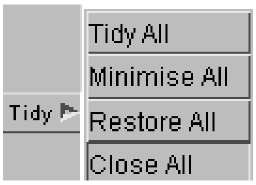
"Docked menus appear in the Current Menu Panel, and hence do not obscure the graphics area. Up to eight such menus can be present concurrently; these are positioned on top of one another. Each menu has a corresponding tab in the Menu Tabs area, and can be bought to the fore by clicking on its tab,

The Model menu is always present; other menus are invoked by the user. When eight menus are active, invoking a ninth menu will cause the least-recently invoked menu to be dismissed automatically.

2.4.3 Iconisation of Menus



Menus can be iconised by clicking ▭ . Click ▣ to restore them.
Alternatively a list of options is produced by clicking on the button in the top-left corner.
Pressing **I** will iconise all windows or if restore them all if they are all already iconised

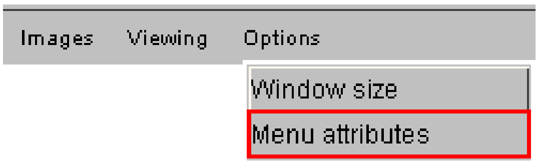


In the Viewing and Drawing Commands box the Tidy menu (invoked by right-clicking)presents several options for handling menus. **Tidy All** iconises all floating menus and positions them in the top left of the graphics area (left clicking on **Tidy** invokes this function). **Minimise All** iconises the menus but does not move them. **Restore All** and **Close All** restore and close all floating menus respectively.

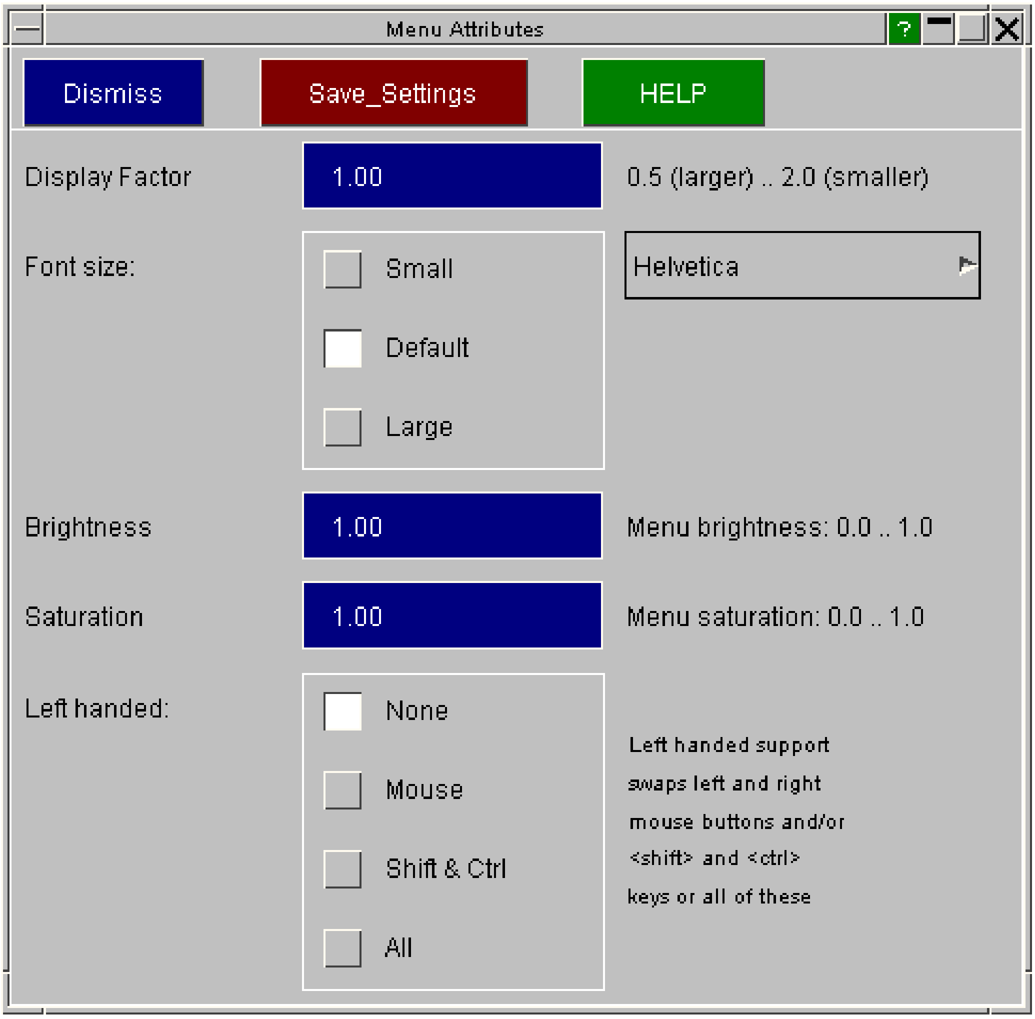
2.4.4 Customising the User Interface

2.4.4.1 Customising Menu size, fonts, colour and handedness

As described in section 1.2 the scale of the menu interface, the font typeface and size, and also the left-handedness of the menu interface may be customised interactively using **Options > Menu Attributes.**



Gives the menu attributes panel:



Display Factor 1.00 0.5 (larger) .. 2.0 (smaller)

Font size: □ Small ■ Default □ Large Helvetica

Brightness 1.00 Menu brightness: 0.0 .. 1.0

Saturation 1.00 Menu saturation: 0.0 .. 1.0

Left handed: ■ None □ Mouse □ Shift & Ctrl □ All

Left handed support swaps left and right mouse buttons and/or <shift> and <ctrl> keys or all of these

Display Factor	Is a factor on the overall scale of the display, lying in the range 0.5 to 2.0, default 1.0. Larger values make the display seem bigger to the software, resulting in smaller menu panels and fonts. Smaller values increase the size of menu panels, buttons and fonts, and can be useful for the visually impaired. This factor can be especially useful on "wide screen" displays with very asymmetric horizontal and vertical resolutions.
Font size	Controls the size of fonts used in the menu interface (but not for graphics). This works independently of the Display Factor, allowing further fine-tuning of the appearance of the user interface.
Font Typeface	For most applications the default Helvetica (Arial on Windows) will suffice. But you can also choose Times or Courier, and Bold variants of all of these.
Brightness **Saturation**	These affect the overall brightness and also the colour saturation of the user interface. They both lie in the range 0.0 to 1.0, default 1.0.

Left-Handed support	By default FOLDER is set up for right-handed usage, which has influence on both mouse buttons and the keyboard "meta" keys: <shift> and <ctrl>. (The left and right meta keys have different functions during dynamic viewing: see section 9.4) You can swap the handedness of mouse and/or meta keys, which will reverse them in the left <=> right sense. **Note**: This swapping is local to FOLDER, and is applied after any system user interface configuration. So if you configure your computer to swap mouse buttons globally, then swap them here, the net effect will be to have unswapped buttons again!

Saving Menu Attributes settings

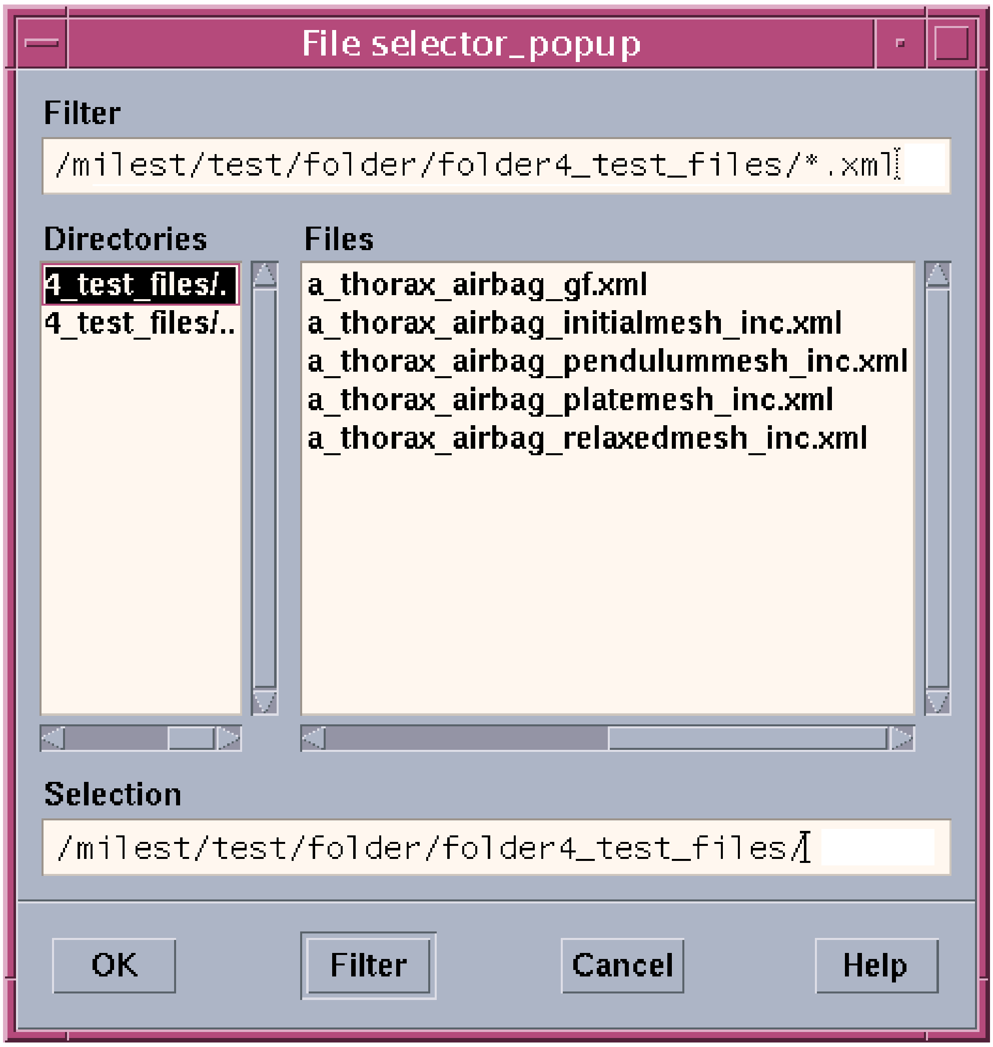
The attributes above may be saved by using **Save_Settings**. Subsequent sessions of FOLDER will pick these up and re-apply them.

For backwards compatibility these attributes may also be set using environment variables as described in Appendix IV. Where conflicting settings exist those generated by the panel above will "win".

2.5 Using standard "file filter" boxes.

Wherever FOLDER requires you to enter a filename you will be presented with a text box into which to type it. However, to the right of this text box you will also see a button with an image of a yellow folder, which may be used to invoke a standard file filter box. The appearance of this is operating system dependent.

2.5.1 Standard "X11" (Motif) file filter box



Filter
/milest/test/folder/folder4_test_files/*.xml

Directories
4_test_files/.
4_test_files/..

Files
a_thorax_airbag_gf.xml
a_thorax_airbag_initialmesh_inc.xml
a_thorax_airbag_pendulummesh_inc.xml
a_thorax_airbag_platemesh_inc.xml
a_thorax_airbag_relaxedmesh_inc.xml

Selection
/milest/test/folder/folder4_test_files/

The "filter" is the pathname and wildcard search pattern to be used. Here the pathname is

`/milest/test/folder/folder4_test_files` and the pattern is `*.xml` (to look for a MADYMO v6.x input file).

The "directories" area lists those directories which exist under the current pathname. Here there are a number of directories eg "." (Unix for "this directory"), and ".." (Unix for "parent directory") .

The "Files" area lists those files in the current directory which match the search pattern.

The "Selection" box shows the current selection.

You select a directory by clicking on it, then clicking on Filter in order to apply your selection. This updates the "Files" box accordingly. You then select a file by clicking on its name in the "Files" area, and finally on OK to make it your choice and return.

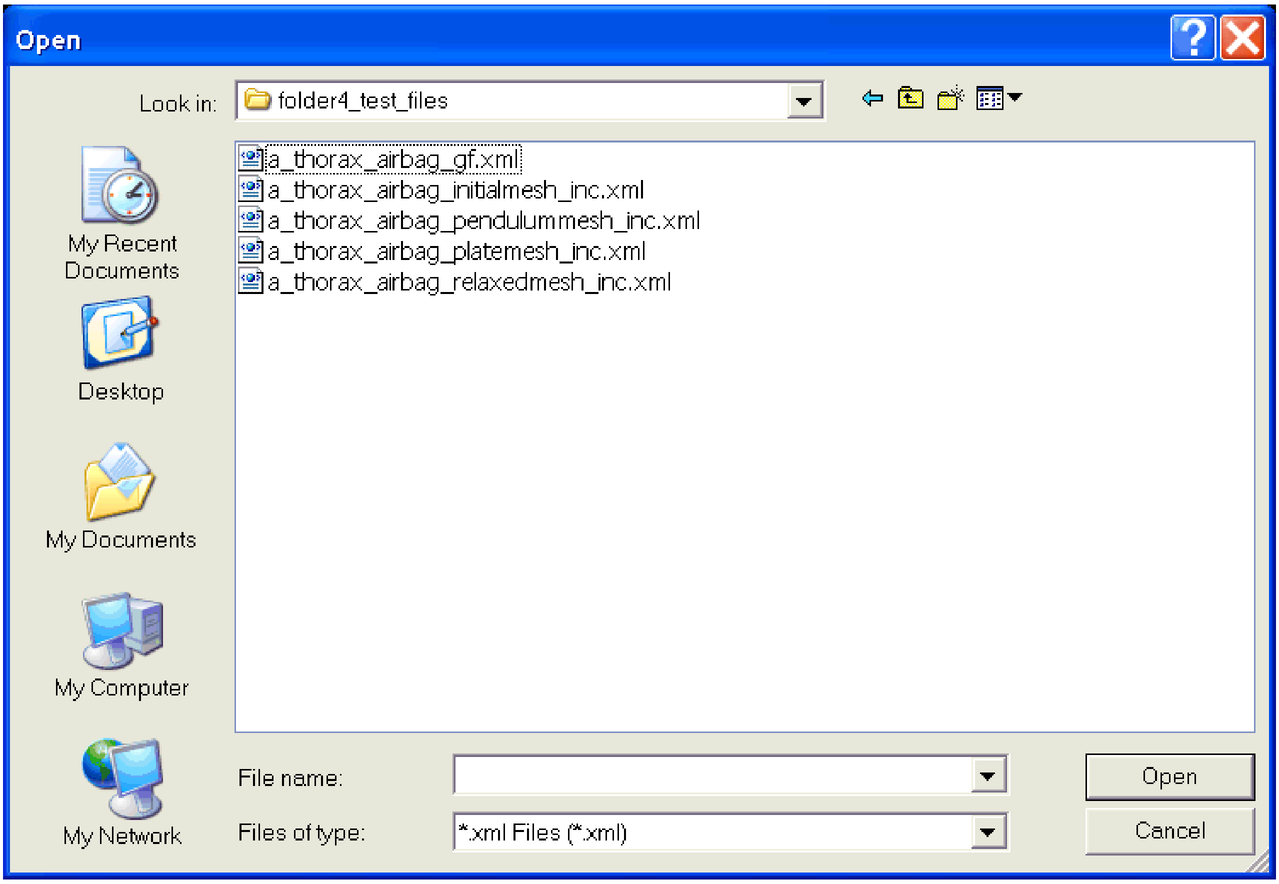
To go back up the directory tree you need to select the ".." (ie parent) directory.

As an alternative to using Filter and OK you can double-click (quickly) on the relevant directory or pathname to make your selection.

Cancel Cancels this operation and returns with no file selected;

Help Provides context-dependent help and advice, then returns to file selection.

2.5.2 Standard "Windows" file filter box



Look in: folder4_test_files

a_thorax_airbag_gf.xml
a_thorax_airbag_initialmesh_inc.xml
a_thorax_airbag_pendulummesh_inc.xml
a_thorax_airbag_platemesh_inc.xml
a_thorax_airbag_relaxedmesh_inc.xml

File name:

Files of type: *.xml Files (*.xml)

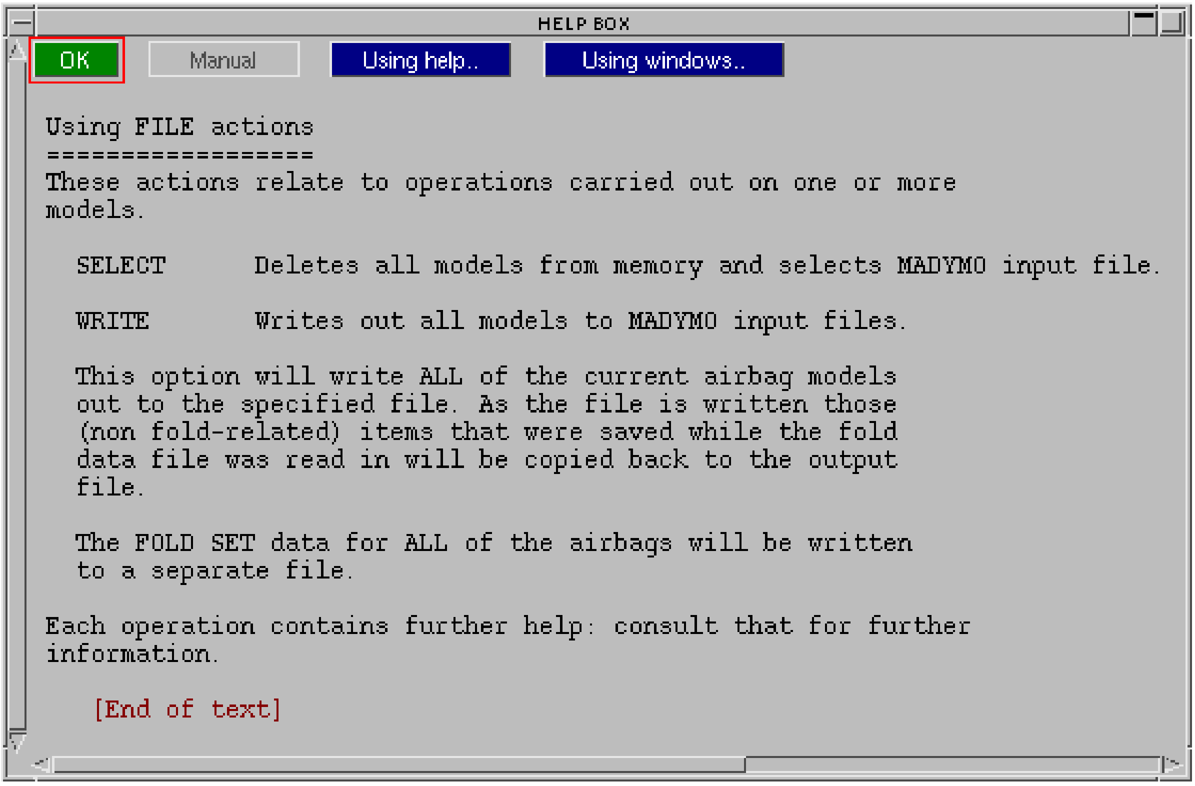
Double-click on the directory required, then on the filename you wish to open.

To open files that do not have the (**`*.xml`**) extension you will need to select:

All files (*.*) from the **Files of type** pull -down menu.

2.6 Obtaining Help and advice.

FOLDER has extensive on-line help available. In any context you will find either a **HELP** button or a [**?**] (on a green background) that will give access to help. Generally speaking it will map a "Help Box", as shown in the example below, and input will be locked into that box until you click on **OK** (or hit <`return`> in that box).



```
Using FILE actions
==================
These actions relate to operations carried out on one or more
models.

  SELECT      Deletes all models from memory and selects MADYMO input file.

  WRITE       Writes out all models to MADYMO input files.

  This option will write ALL of the current airbag models
  out to the specified file. As the file is written those
  (non fold-related) items that were saved while the fold
  data file was read in will be copied back to the output
  file.

  The FOLD SET data for ALL of the airbags will be written
  to a separate file.

Each operation contains further help: consult that for further
information.

   [End of text]
```

2.7 Error and Warning messages

Occasionally you will get error or warning messages. These are written to the dialogue box in red, prefaced by `%%% ERROR` or `%%% WARNING` respectively.

Internal errors (let us hope you never see any) are also copied to standard output, ie the terminal window from which FOLDER has been invoked. If you get any of these please make a copy of them and inform Oasys.

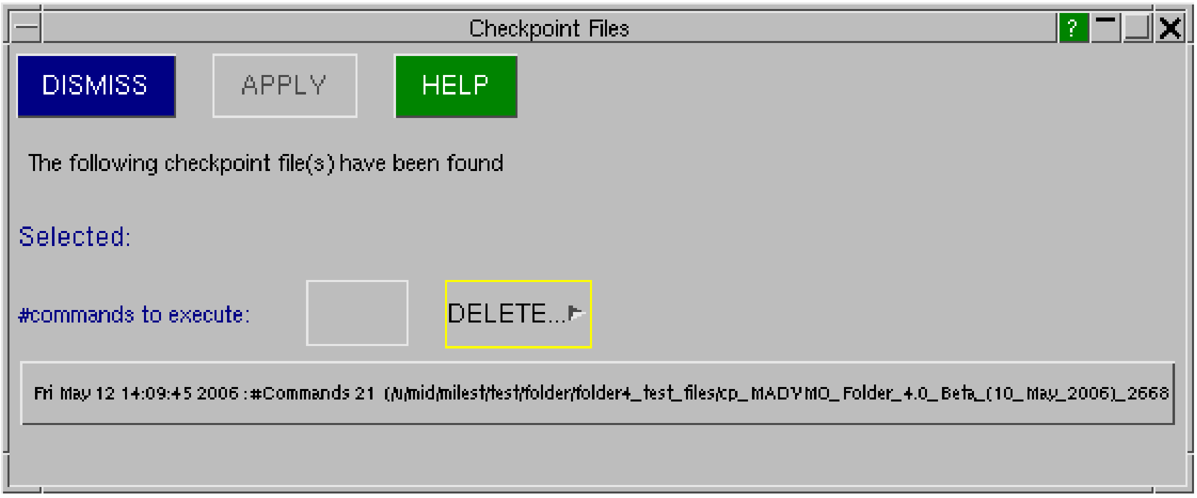
2.8 Checkpoint/Recovery files

All commands of your FOLDER session are recorded in a binary (non-editable) checkpoint or recovery file (CP_FOLDER_4.0_xxx). If the session terminates normally the file is automatically deleted. If the software crashes, the file will be left behind.

When you next start FOLDER, you will be offered the option of rerunning any existing checkpoint files. Do not forget to **remove the last command**, by decrementing the *#commands to execute* counter or the crash will simply repeat.

Note that if you have overwritten your original file during the session, rerunning the command file will not be helpful.

In some cases, sending the checkpoint file and the input files to Oasys will assist in debugging the software.



The following checkpoint file(s) have been found

Selected:

#commands to execute:

Fri May 12 14:09:45 2006 :#Commands 21 (/u/mid/milest/test/folder/folder4_test_files/cp_MADYMO_Folder_4.0_Beta_(10_May_2006)_2668

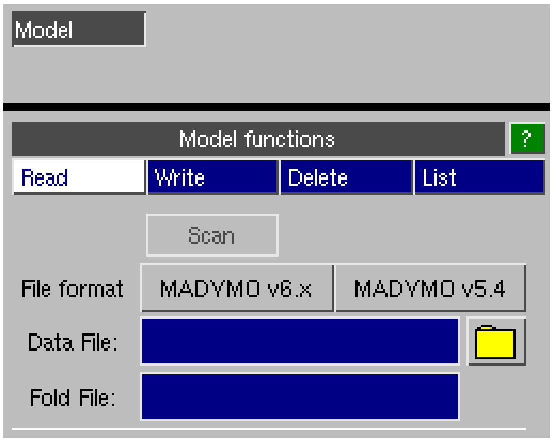
If you rerun someone else’s checkpoint file on a different computer you are likely to find that it fails because any files opened will have an incompatible path. Setting the environment variable:

`CP_FILE_FILTER true`

Will cause FOLDER always to map the file selection box whenever a file is opened, allowing you to read in files from a different file system.

Note: Checkpoint files should be cross-platform, ie a file generated on machine A should replay on machine B; however they are ***not*** cross-version, and will only work with exactly the same version of the software.

3 Model manipulation



The **MODEL** menu

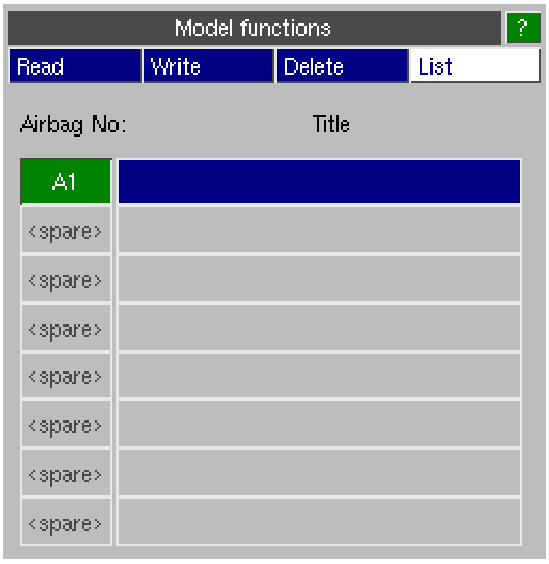
3.0 How FOLDER treats "models"

FOLDER is unusual in that it permits you to work with concurrent multiple airbags.

A "airbag" within FOLDER consists of only the COORDINATE, REFERENCE COORDINATE, ELEMENT and STRAP definitions within a MADYMO airbag model.

Only ONE MADYMO file can be read into FOLDER at any time. This file may contain up to 255 airbag models each of which is stored separately within FOLDER and can be manipulated independently. Any non-airbag models within the MADYMO input deck will be ignored.

Any unprocessed models and the items that are not processed within airbag models are copied to temporary scratch file that is given the same name as the Madymo input file plus the suffix "_scratch". When the folded airbags are written back out from FOLDER all of the unprocessed items within the scratch file are added back into the output file.



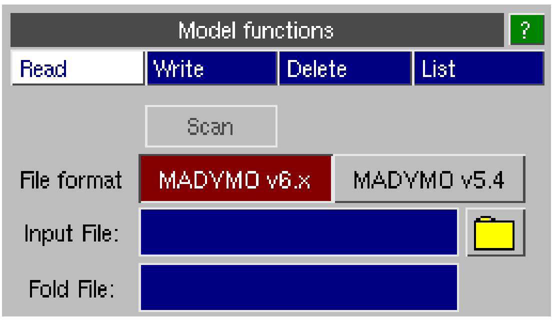
Airbags are controlled and displayed from the MAIN box as shown in the adjacent figure.

In this example there is currently one airbag in memory. If more than 10 are currently loaded into memory then a scroll-bar will be added to the window.

The "Airbag No:" column shows the ids of each model (Annn), and the "Title" column shows their current titles.

If the "Airbag No:" entry button is selected (as it is here) then that model is available for display. If de-selected then that model will not be drawn. This is the highest level of display control, and provides a quick and easy method of un-cluttering the display.

3.1 Model> Read



Reading in models from disk.

The READ menu allows two file names to be specified, a MADYMO data file and a FOLD file. (The FOLD file is a special file used by FOLDER that contains information required to fold an airbag.)

FOLDER can read version 6.x MIFF/XML files and version 5.4 data files.
Specify the format that you want to read by using the File format buttons.

Note : A FOLD file does not have to be read in.
When a MADYMO XML/data file is selected FOLDER will automatically check to see if a matching FOLD file exists (using the extension .fold). If it does exist then it will automatically be selected. If the user wishes to use a different FOLD file, or does not want to read a FOLD file then the FOLD file name can still be modified or deleted.

3.1.1 Reading version 5.4 files

When the user selects **Apply** the following actions take place

1. For version 5.4 files the MADYMO data file is scanned to see if it contains any airbag models. If the file does not contain any airbag models a warning message is generated. The user is then given the chance to select another data file.
2. The MADYMO data file is processed and the following data for any airbag models is read in.
   REFERENCE COORDINATES
   COORDINATES
   ELEMENTS
   STRAPS
   (All other data for an airbag model and any non airbag models is copied to a scratch file)
3. After reading the Madymo data file the FOLD file, if specified, will be read in and processed.
4. After reading the FOLD file a check will be carried out and if there are any airbag models that do not have at least one FOLD SET defined then a default FOLD SET containing the complete model will be created.

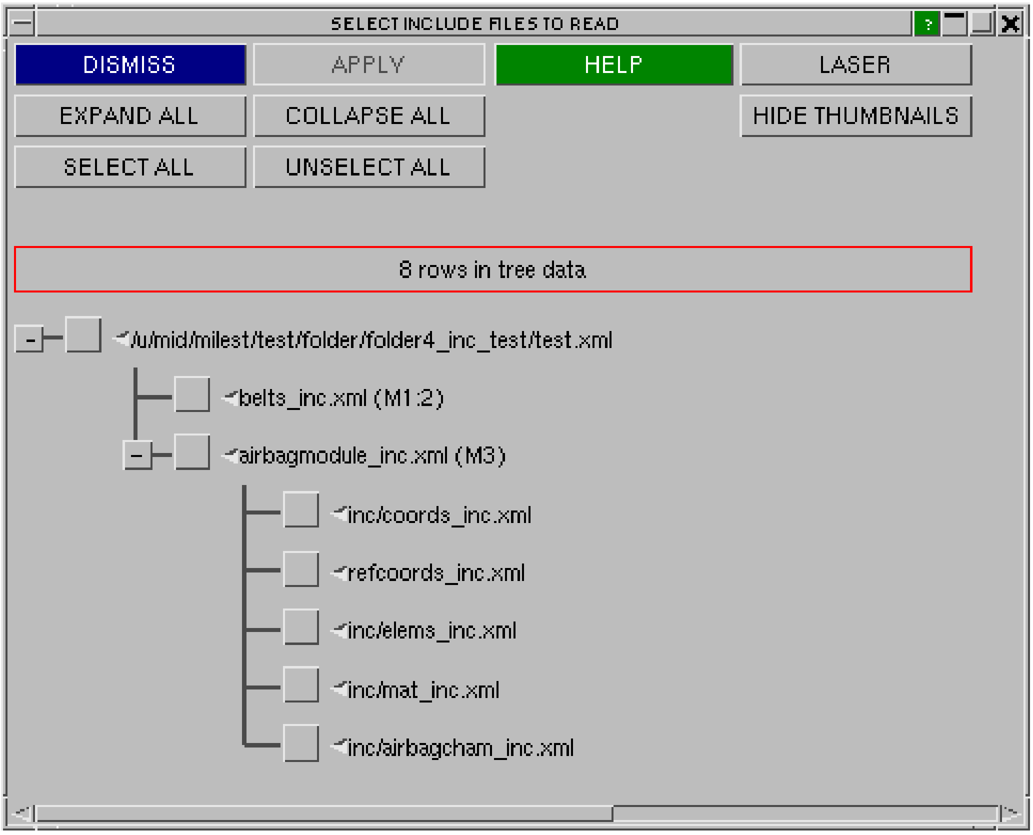
3.1.2 Reading version 6.x files

When the user selects **Scan** the following actions take place

1. Folder scans the XML file to look for include files. If there are no include files (or if you are reading a single include file) the file is processed (see (2)). If there are include files then a tree is displayed to allow the user to select which files to read (see next section)
2. The MADYMO XML file is processed and the following data for any airbag models is read in.
   REFERENCE COORDINATES
   COORDINATES
   ELEMENTS
   (All other data for an airbag model and any non airbag models is copied to a scratch file)
3. After reading the Madymo XML file the FOLD file, if specified, will be read in and processed.

3.1.3 Reading version 6.x files with include files

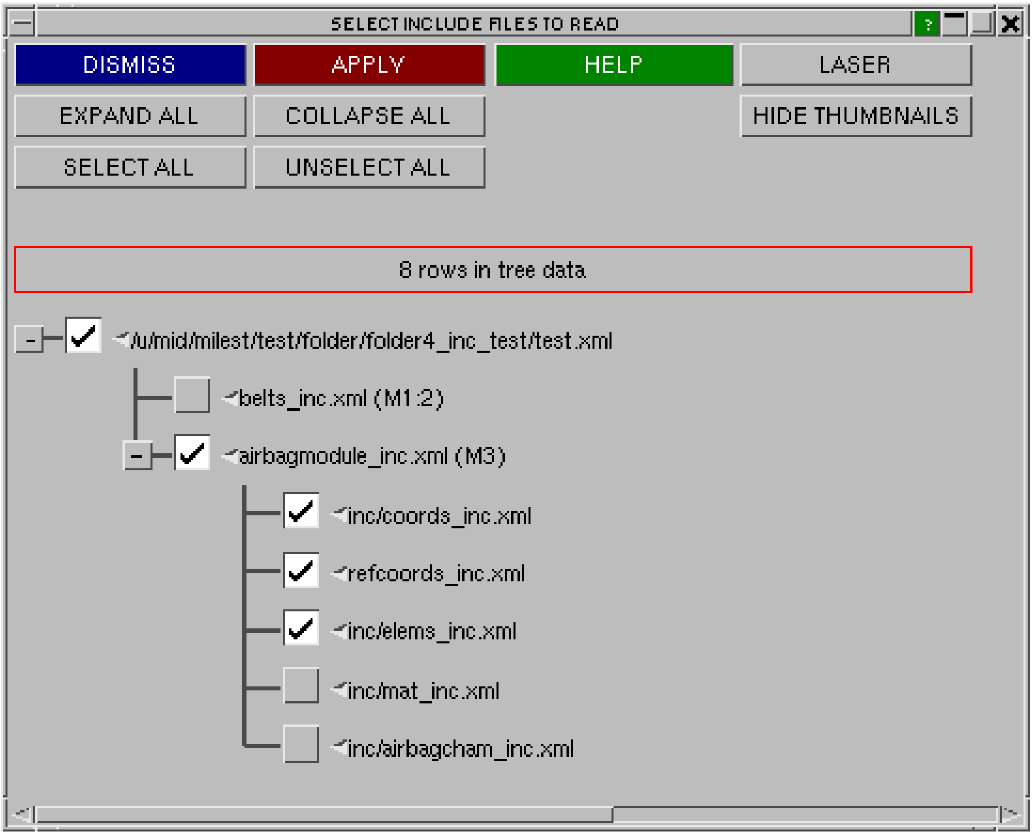
If the XML file you are reading contains include files a window with a "tree" view of the include files is shown after initially scanning the file.
For example the picture below shows an XML file containing 7 include files. In this example the include file "airbagmodule_inc.xml" itself contains include files.



8 rows in tree data

- □ /u/mid/milest/test/folder/folder4_inc_test/test.xml
  - □ belts_inc.xml (M1:2)
  - □ airbagmodule_inc.xml (M3)
    - □ inc/coords_inc.xml
    - □ refcoords_inc.xml
    - □ inc/elems_inc.xml
    - □ inc/mat_inc.xml
    - □ inc/airbagcham_inc.xml

Select which include files you want to read by clicking on the boxes.
For example in the picture below, the main file and 4 include files are selected to read. In this example the coordinates are in include files "inc/cords_inc.xml" and "refcoords_inc.xml", and the elements are in "inc/elems_inc.xml". These are the only files we need to read if we just want to overwrite the files when saving from folder. However, if we wanted to save the coordinates to a different file (for example "new_cords.xml" we need to also read the parent include file "airbagmodule_inc.xml" and the main file so we can change the INCLUDE tags in those files to the new values. If you do not read them and you save the include files to different names you will have to update the tags manually.



8 rows in tree data

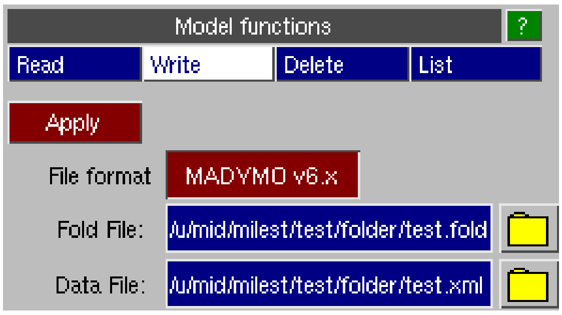
- ☑ /u/mid/milest/test/folder/folder4_inc_test/test.xml
  - □ belts_inc.xml (M1:2)
  - ☑ airbagmodule_inc.xml (M3)
    - ☑ inc/coords_inc.xml
    - ☑ refcoords_inc.xml
    - ☑ inc/elems_inc.xml
    - □ inc/mat_inc.xml
    - □ inc/airbagcham_inc.xml

When you have selected the include files you want to read press **APPLY** and the process then proceeds as normal.

3.2 Model > Write

Writing out airbags to disk.

All internally stored airbags can be written out at any time using the **Write** option.
This invokes the WRITE TO FILE panel shown on the right.
In this example only a single file is selected to write. If you have read multiple include files the panel will be different (see section 3.2.1).



File format MADYMO v6.x

Fold File: /u/mid/milest/test/folder/test.fold

Data File: /u/mid/milest/test/folder/test.xml

This operates in the same fashion as file reading:

- Select a name for the MADYMO output file;
- Select a name for the FOLD file;
- Click on APPLY

If the file already exists you are given the choice of overwriting it or giving a new filename.
You can only write out the file in the same format that it was read in. In the above example a version 6 XML file was read. There are two exceptions to this:

1. When a star fold is created. In this case as FOLDER creates the model from scratch it can be written out in version 5.4 or version 6.x format.
2. When a circular mesh is created for mesh independent folding. This must be written in version 6.x format

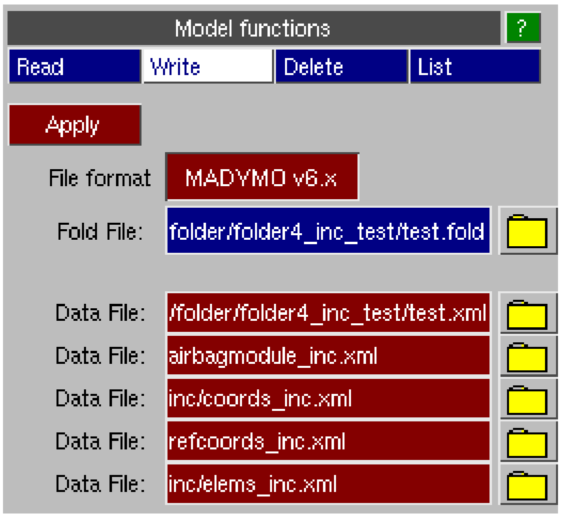
Writing out a model does not usually affect its contents in memory in any way.

3.2.1 Writing multiple include files

If multiple include files have been read from a version 6.x file the write panel looks slightly different.

Each of the files which have been read is shown in the panel (this is the panel shown when writing the files that were read in the example in section 3.1.3)
Each file that was read will be written back out (remember that you do not need to read all the files, just the ones relevant to the airbag).

The file names are shown on a red background to indicate that you are overwriting the original file



File format MADYMO v6.x

Fold File: folder/folder4_inc_test/test.fold

Data File: /folder/folder4_inc_test/test.xml

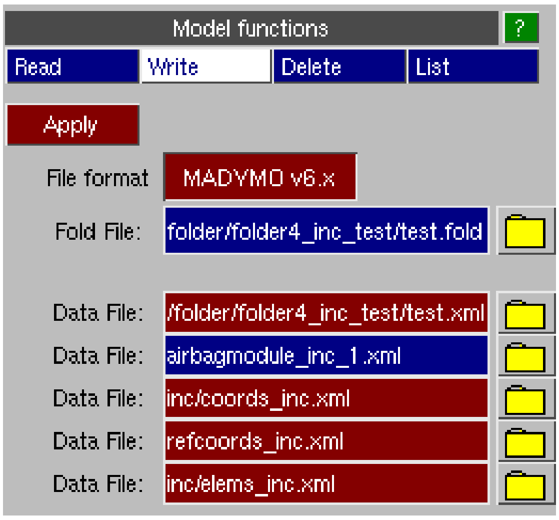
Data File: airbagmodule_inc.xml

Data File: inc/coords_inc.xml

Data File: refcoords_inc.xml

Data File: inc/elems_inc.xml

For example, if you do not want to overwrite the file "airbagmodule_inc.xml", change the name in the box or press **?** to select a new file.
The background colour will change to blue to indicate that you are no longer overwriting the original.
Once you are happy with all the file names, pressing **Apply** will write the files.



File format MADYMO v6.x

Fold File: folder/folder4_inc_test/test.fold

Data File: /folder/folder4_inc_test/test.xml

Data File: airbagmodule_inc_1.xml

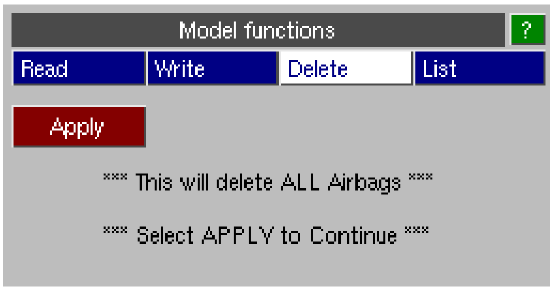
Data File: inc/coords_inc.xml

Data File: refcoords_inc.xml

Data File: inc/elems_inc.xml

3.3 Model > Delete

This option will **DELETE ALL** of the airbag models that are currently defined in FOLDER.
In addition to deleting the airbags within FOLDER this option will also delete the scratch file containing unprocessed items that was created when the MADYMO input file was read in.



*** This will delete ALL Airbags ***

*** Select APPLY to Continue ***

3.4 Operations on models

Once in memory models can be drawn; they can also be translated, rotated, reflected and scaled via the **ORIENT** command. Models may also be deleted, and their contents edited in a variety of ways. These and other operations are described elsewhere in the manual.

3.5 Viewing models

Models become visible as soon as they have been read in.

The default action when an airbag is input is to calculate its max/min dimensions, then to display it, autoscaled if necessary, in the current plotting mode.

There are a range of commands which affect what is visible, how it is drawn and what labelling takes place. These are described in section 4, but a summary is:

- Model visibility is controlled globally via the "**Annn**" buttons under **MODEL** > **LIST**. When depressed (green) a model is potentially available for viewing, when up (red) the model is removed from the view list.
- Classes of entity (eg Shells, Membranes, straps, etc) may be made visible and, optionally, labelled using the Entity Visibility controls. These flag an entity class for display and/or labelling across all models. This panel can be accessed by the shortcut key E, the top bar menu **DISPLAY** > **ENTITIES** or the button **ENT** from the viewing drawing window.
- Any item, or range of items, can be made visible or invisible using the **BLANK** command. "Blanking" may be applied in a hierarchical fashion to models, or subsets thereof, down to individual items. See Section 4.5 for more information on Blanking.

Basic drawing itself takes place in one of three modes:

- **LI**ne "Wireframe", with no hidden-surface removal.
- **HI**dden Also wireframe, but with hidden surface removal applied.
- **SH**aded 2D and 3D items are drawn shaded and lit, with 1D and other items superimposed in hidden mode.

In addition items may be **SKETCH**ed on top of the current image. "Sketching" superimposes a wireframe (unhidden) sketch of the relevant items on top of the current image, in an alternate colour and without clearing the current image. Sketching is not affected by the entity switches or blanking settings.

Data-bearing items may also be contoured or otherwise displayed using:

- Continuous Tone (**CT**) or Shaded Image (**SI**) contour plots, for example of max principal strain, etc.

4 Model visualisation

Master Index

4.0 Visualisation and labelling.

This section describes how to draw airbags, control what is drawn, and also add labels and associated data to plots. Viewing control is covered in section 8.

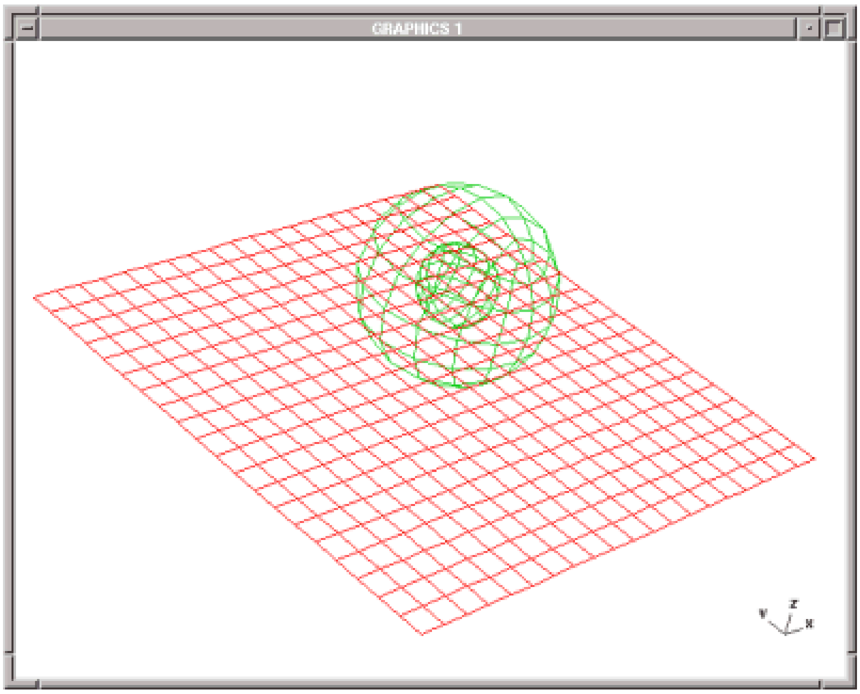
4.1 Basic drawing commands: LI(ne), HI(dden line), SH(aded image)

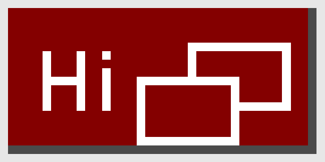
FOLDER is capable of drawing basic airbag geometry in three modes: "**LI**ne", "**HI**dden-line" and "**SH**aded".

"LINE" mode (**LI**) draws all element borders with no hidden surface removal. However the back faces of 3D elements are removed when graphics are in 2D mode (but not in 3D mode).

This figure shows an example of a line mode plot of two round airbags above a flat airbag.

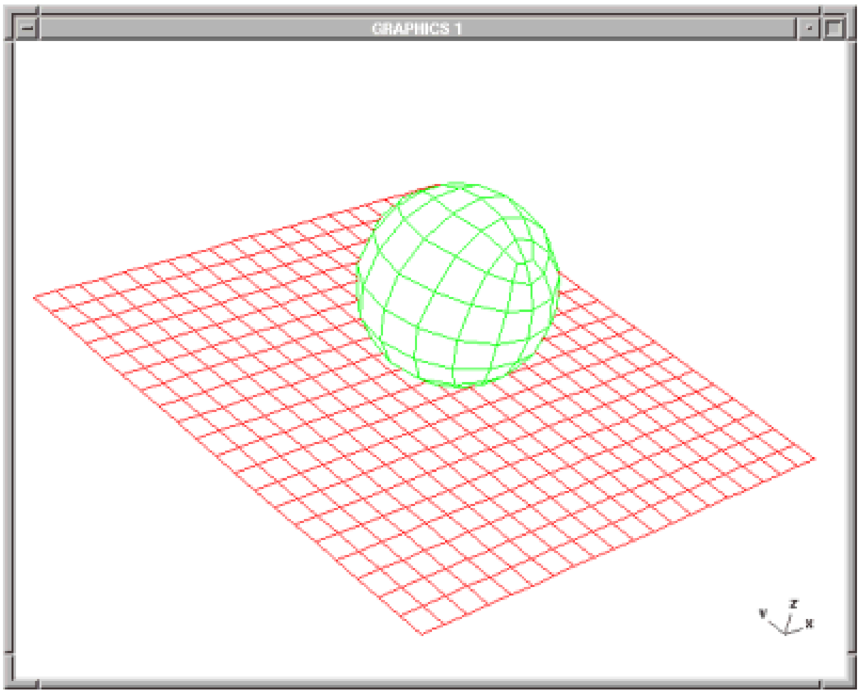
Note that no hidden surface removal has been carried out.





"Hidden-line" mode (**HI**) also draws element borders, but this time with hidden surfaces removed. (Back face removal is implicit in this.)

This figure shows an example of a hidden-line plot, with the same model as above.
It is now obvious that the hidden surfaces and lines have been removed, and it is easy to tell that the round airbag lies above the flat airbag.

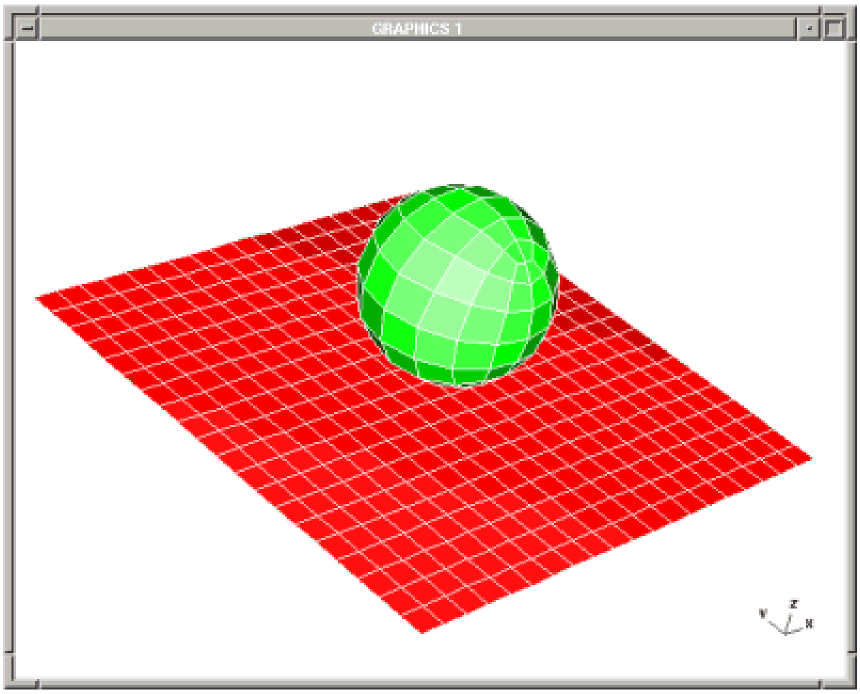


Hidden surface removal requires more computation than a simple line mode plot, so it will be slower to generate. Most displays with 3D graphics protocols have a hardware "Z-buffer" which makes this process faster, but even so complex images may take an appreciable time to draw. For this reason the dynamic viewing modes, which permit real-time manipulation of the view, have a facility to drop back to line mode (or even "free-edge" mode) while the image is being moved, reverting to the normal display mode when the motion is complete. See section 8.4 for a description of how to do this.

Sh

"Shaded" (**SH**) mode also performs hidden-surface removal, but this time the surfaces of 2D and 3D elements are shaded and lit in the appropriate colours.

This figure shows an example of a shaded-image plot. Lighting and hidden-surface removal have both been applied, and the element borders have been overlaid on the resulting plot.

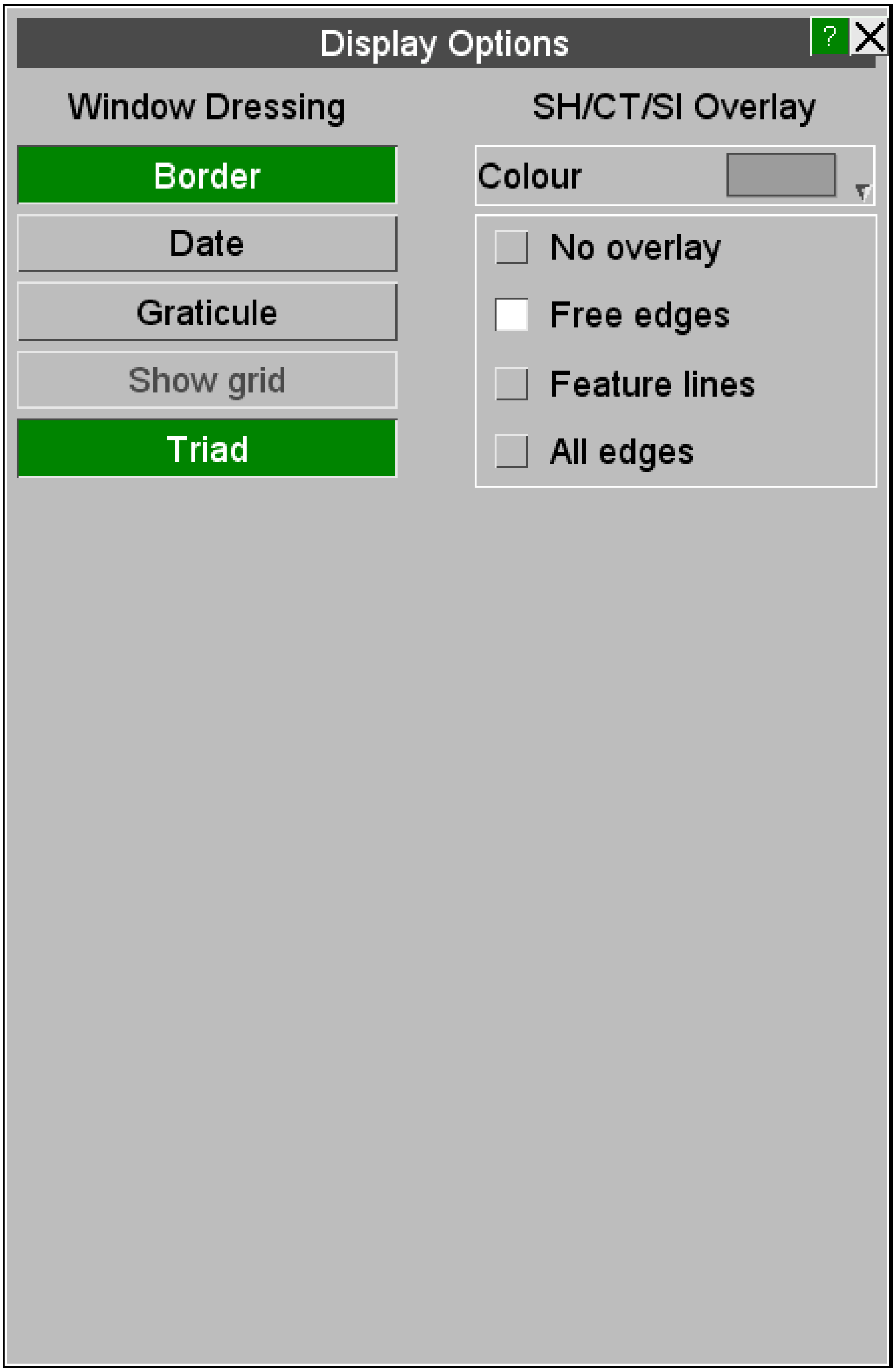


As with hidden-line plots, 3D devices with hardware assistance will generally produce these images much faster than the software alone (2D) method, but (in either mode) computation time will be longer and the ability to drop back to line or free-edge mode during dynamic viewing also applies.

Shaded, Line and Hidden plots may also be invoked with the shortcut keys S,L and H.

4.1.1 OPTIONS... Controlling plot parameters.

"Options" gives user control over a number of graphical features.



Window Dressing Controls the display of the plot border, and display of the current date.
The "**GRATICULE**" is tick marks around the edge of the plot which show the current window dimensions: useful for estimating distances on the screen (although **MEASURE** provides a more accurate method). If the graticule is on then you can also join up the tick marks with **SHOW GRID**.

SH/CT/SI Overlay The element border overlay for **SH**(aded) plots, and also the contoured **CT** (continuous tone) and **SI** (shaded image) is separately controllable.
Its colour may be set via the popup menu to a fixed colour, or to "entity" colours.

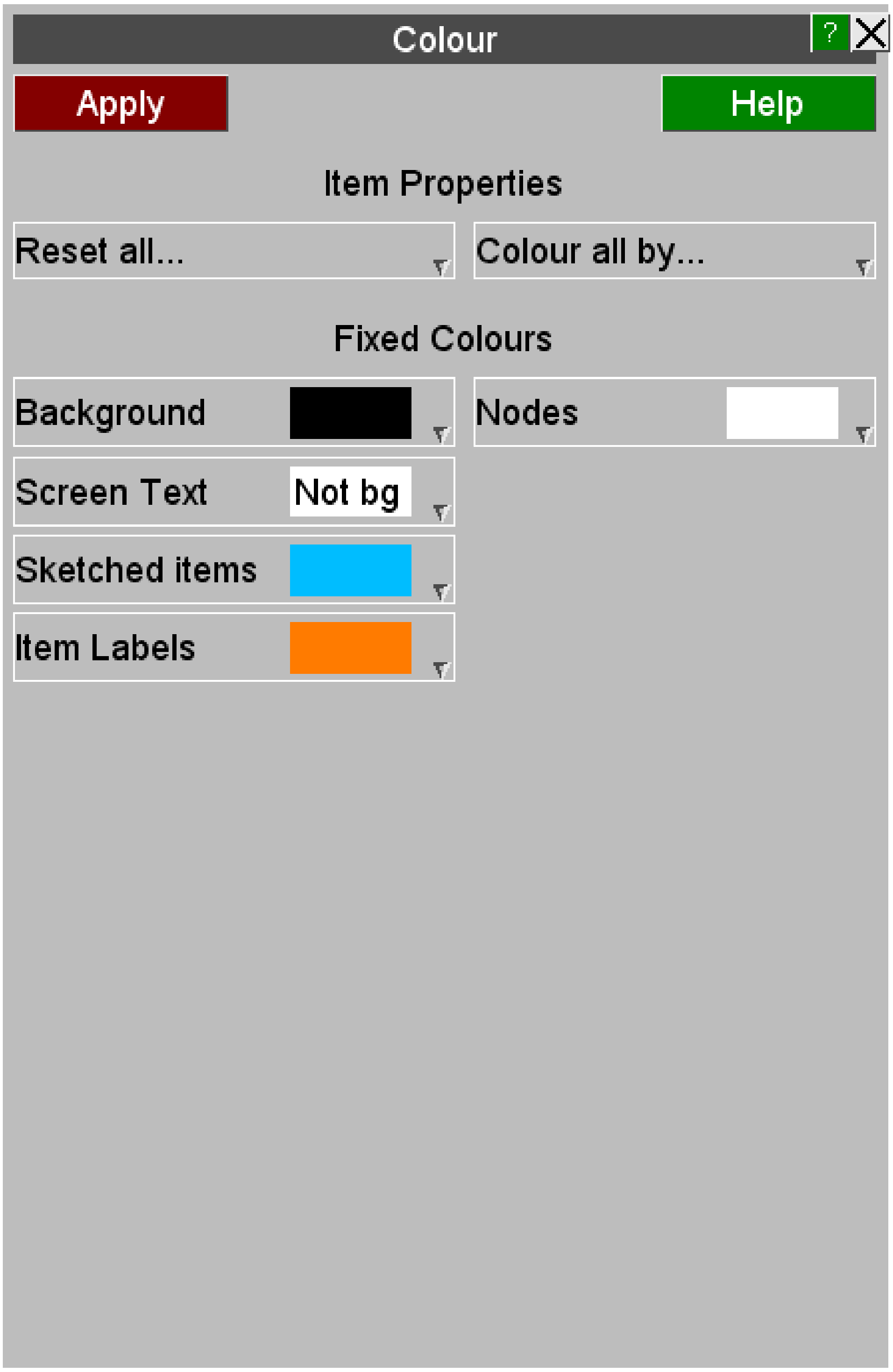
The edging mode may be set to "none", "free edges", "feature lines" or "all edges".

"**Free edges**" are defined where an element edge is not connected to any other element of the same type, or where the part ids of the elements at an edge differ. Therefore a topological plot of the boundaries of mesh zones is produced.

"**Feature lines**" are a superset of "free edge" mode in which the angle between adjacent elements is considered. Where this angle is greater than the "Edge angle" defined above then a feature line edge is defined, and this is added (logically ORed) to the free edges. The effect is to give a better idea of the shape of the mesh than is available from free edges alone.

4.1.2 COLOUR... Setting item colours in plots.

All options in this panel have popup menus giving a range of colours, with the current selection being shown.



Background ⬛

Nodes ⬜

Screen Text Not bg

Sketched items 🟦

Item Labels 🟧

Background Sets the background colour of the graphics window. Default: black

Screen Text Sets the colour for title, date, contour bar values, etc. Default: white.

Sketched Items Sets the colour for anything sketched in any context. By default it is set to "**Not background**", the logical opposite of the current background setting so as to establish good contrast. It can also to be set to a fixed colour or **Use Text Colour** which will use the same setting as **Screen Text** is set to.

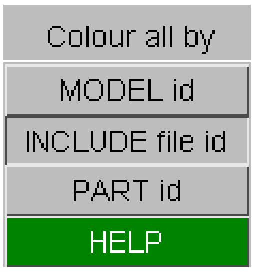
Labels Sets the colour for item (eg node) labels. Default: white.

Colour all by gives options of how to colour model items.

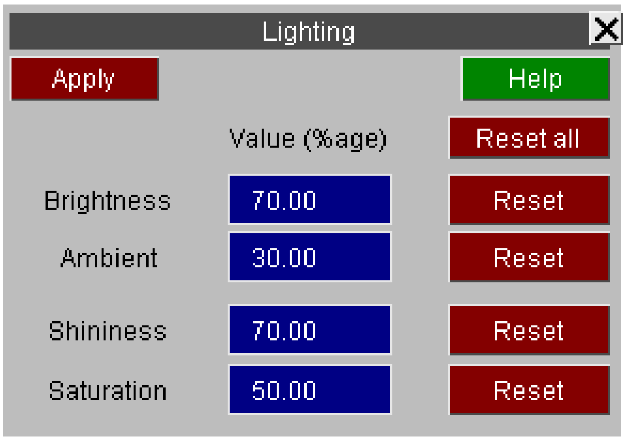
- MODEL id sets colour by model number.
- INCLUDE file id sets colour by which include file items belong to.
- PART id sets part-based element colours by part number

Based on PART id
For element types that use parts the colour may be based on one of the part. The label of the property is used, for example all elements of part 1 will be the same colour. Where a part id is undefined grey is used.

The default is for all such elements to be drawn by **PART** colour.



4.1.3 Lighting



	Value (%age)
Brightness	70.00
Ambient	30.00
Shininess	70.00
Saturation	50.00

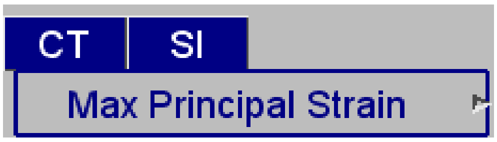
Brightness There is a light source at the observers viewpoint (this direction cannot be altered). This field controls how bright this source is. Facets normal to the observer reflect the maximum amount of light from this.

Ambient This control the level of "black-body radiation" which illuminates all facets equally regardless of orientation.

Shininess Low values will give a matt (dull) appearance, high values a shiny one.

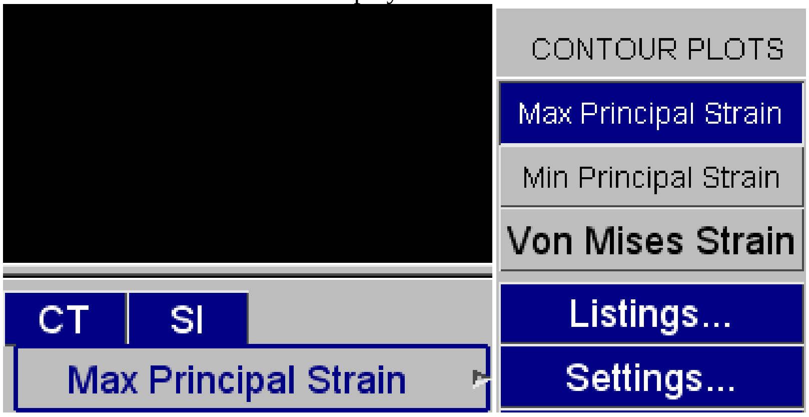
Saturation This controls the ’depth’ of colour in the range pure colour to grey.

4.2 Data Plotting Commands: CT (continuous tone) and SI (shaded image)



Each command has a popup menu that gives some or all of the following options:

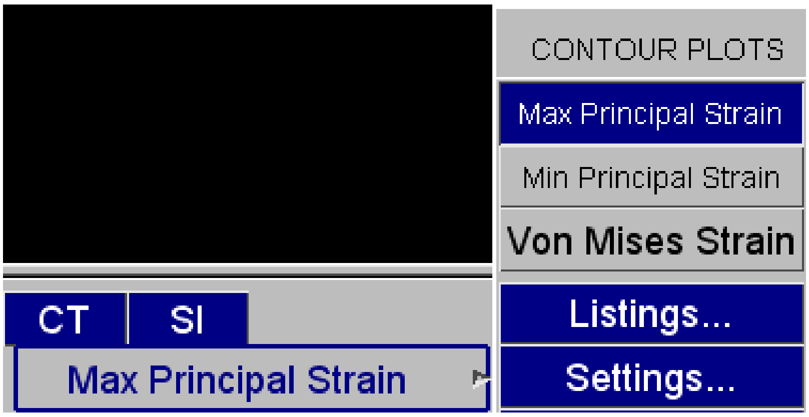
Data component:	Max principal strain etc
Listings...	Written output of displayed data. For example lists of maximum principal strains sorted into ascending order.
Settings...	Unique panels for each data component that control what is drawn and how it is displayed.
Levels...	Control and display of the number of contour levels.



4.2.2 CT and SI plots.

CT (continuous tone) and **SI** (shaded image) plotting modes both display the same data, but the former is unlit whereas the latter is shaded. Both modes are used primarily to display data for 2D and 3D elements, so the underlying plotting mode is always "hidden surface with fill".

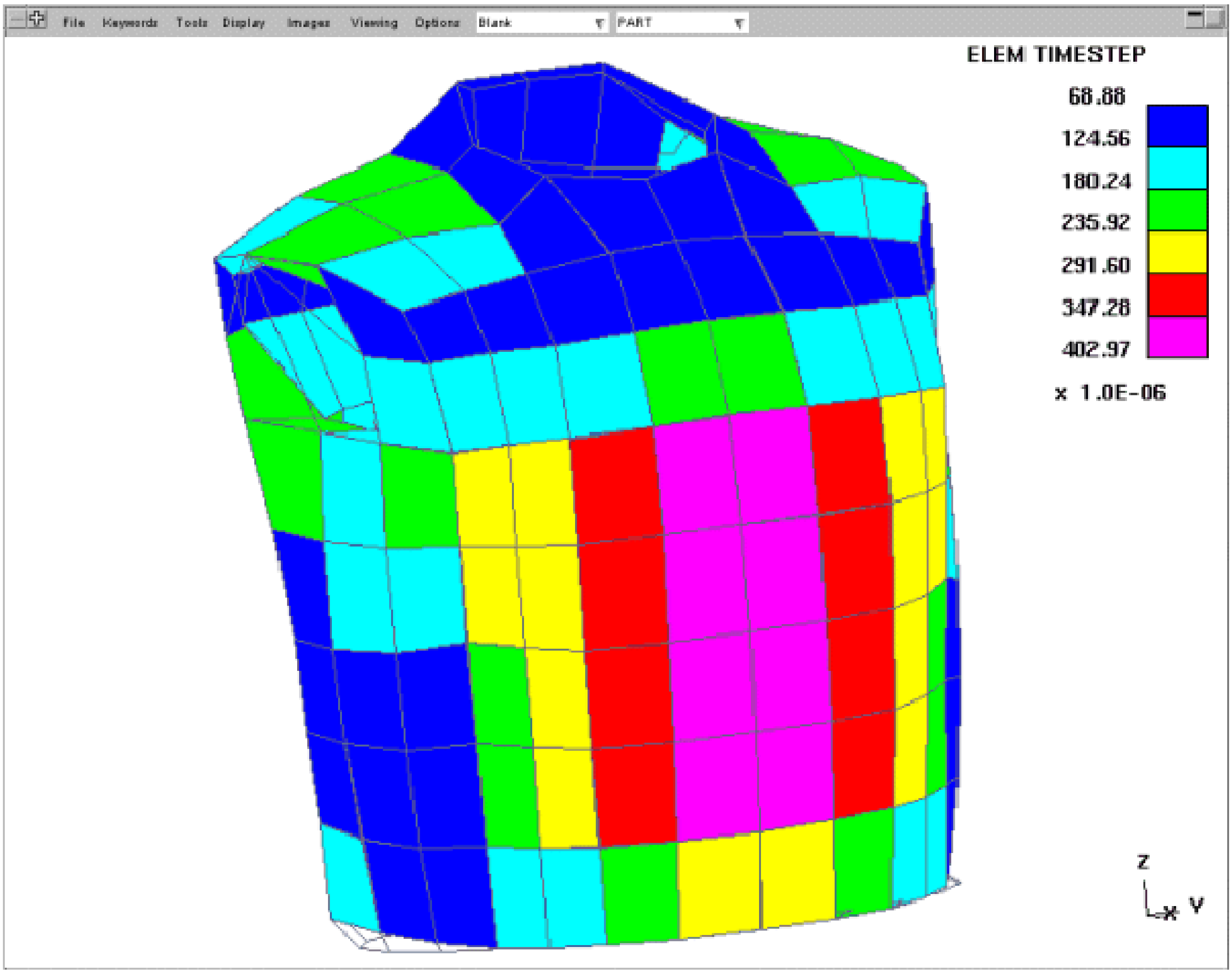
Current data components available are:



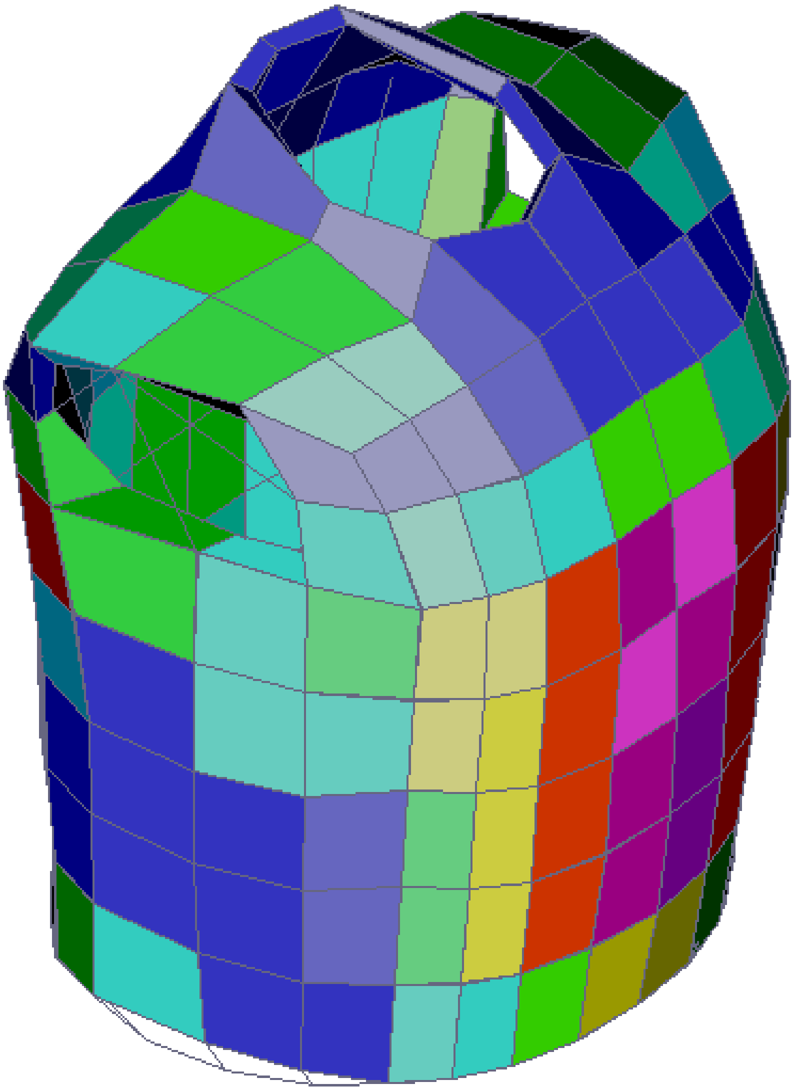
Max Principal Strain	Contours of maximum principal strain in elements
Min Principal Strain	Contours of minimum principal strain in elements

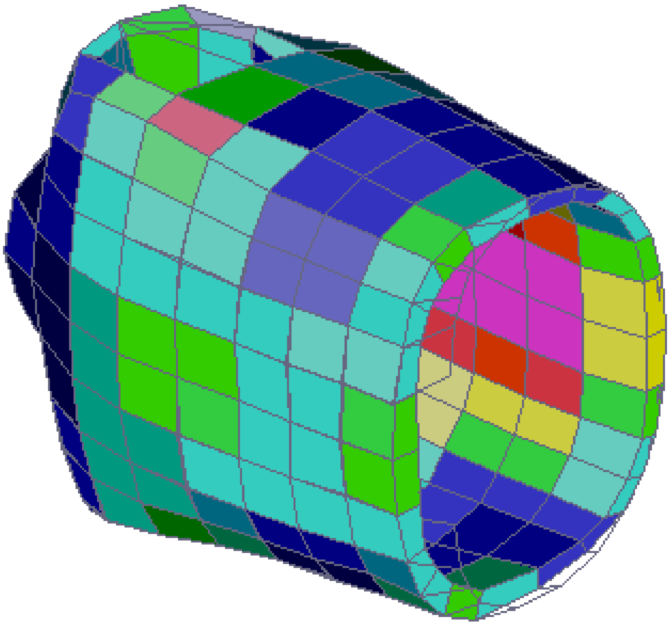
Von Mises Strain	Contours of Von Mises strain in elements

CT plot of maximum principal strains.

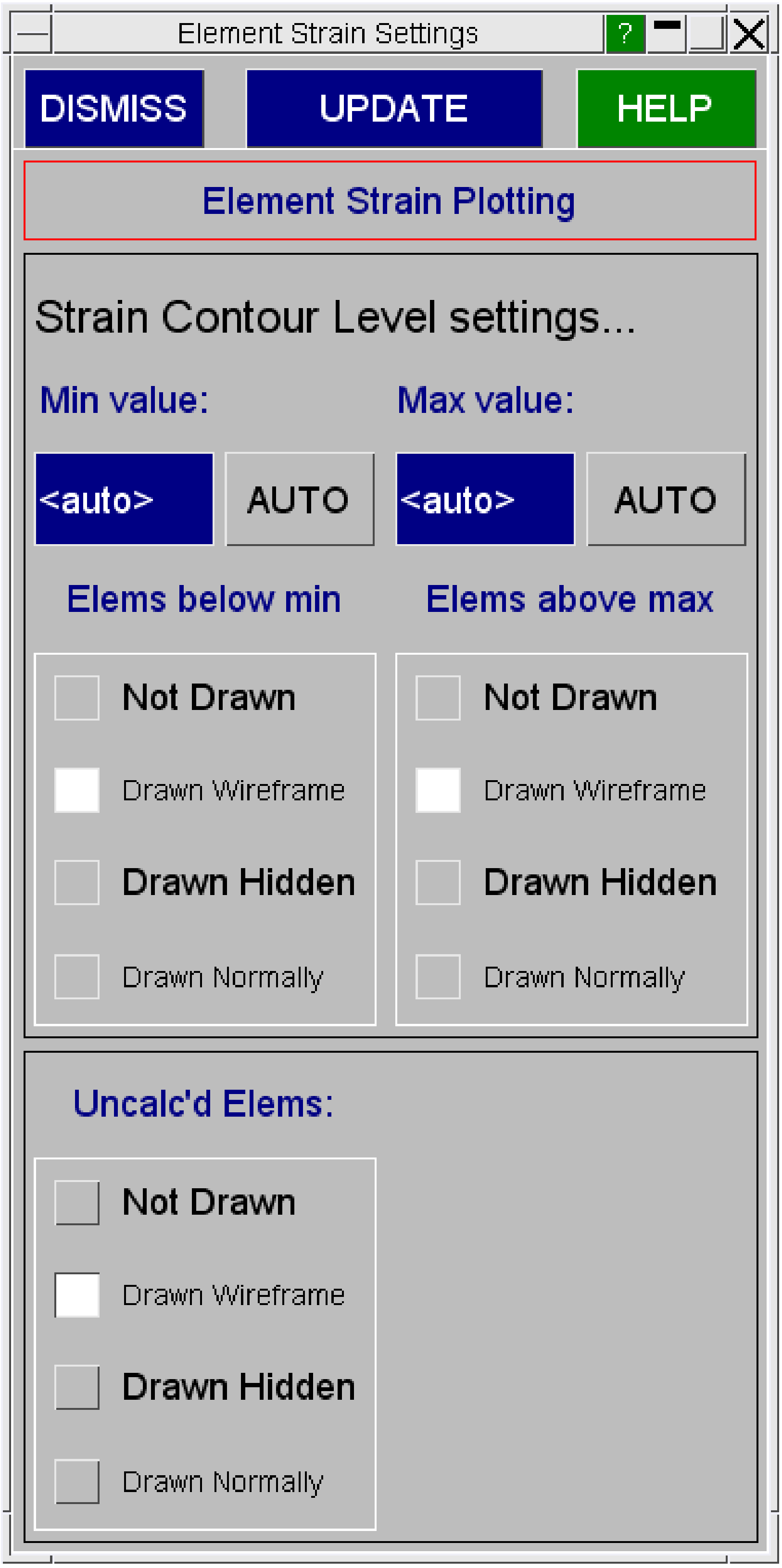


Here is the same image displayed from 2 different angles in **SI** mode, to show how lighting can be integrated with contouring to give a better idea of shape.





Here is the **Settings...** panel for maximum principal strain plotting:



Element Strain Settings

DISMISS UPDATE HELP

Element Strain Plotting

Strain Contour Level settings...

Min value: <auto> AUTO

Max value: <auto> AUTO

Elems below min

□ Not Drawn
☑ Drawn Wireframe
□ Drawn Hidden
□ Drawn Normally

Elems above max

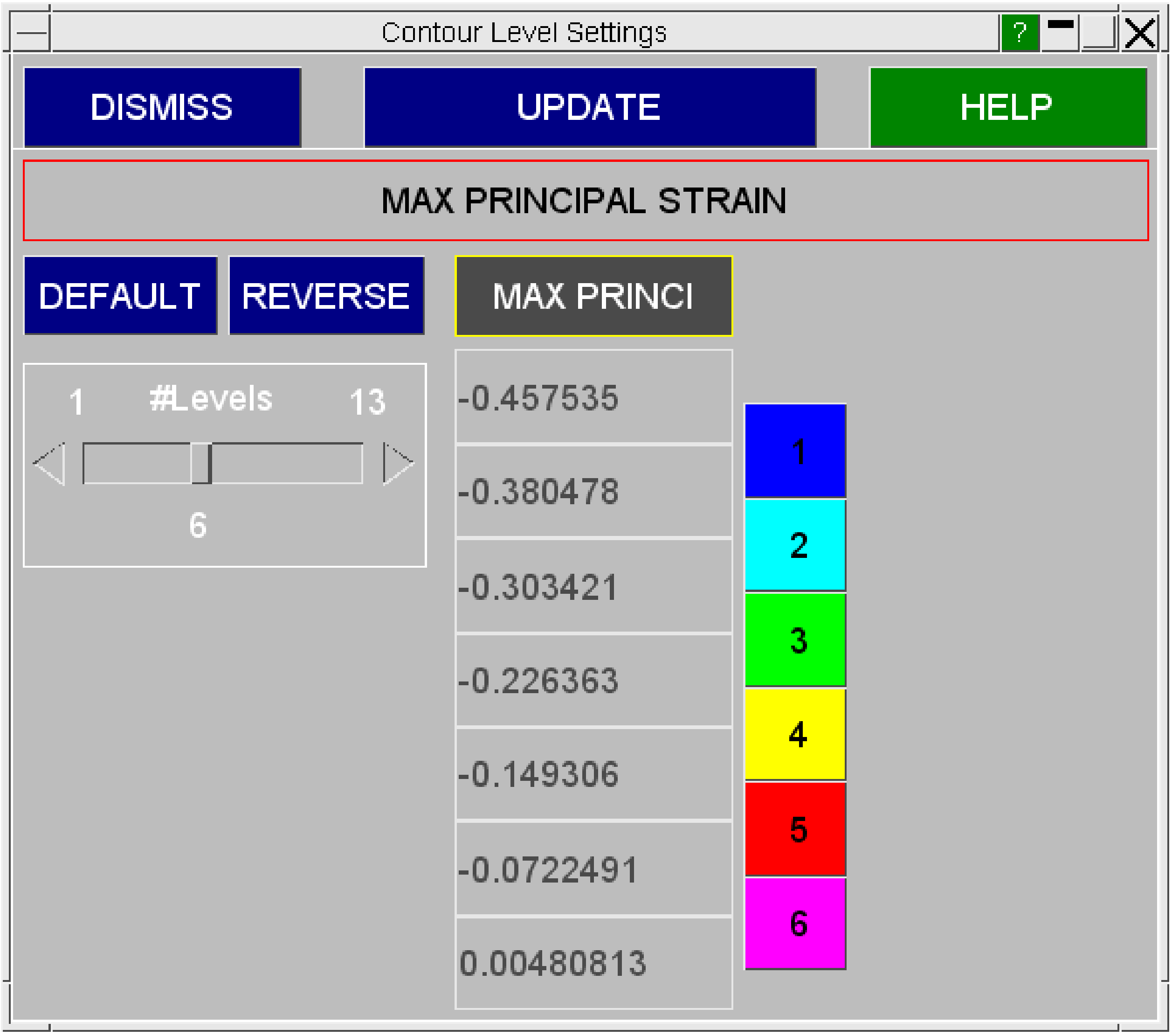
□ Not Drawn
☑ Drawn Wireframe
□ Drawn Hidden
□ Drawn Normally

Uncalc'd Elems:

□ Not Drawn
☑ Drawn Wireframe
□ Drawn Hidden
□ Drawn Normally

The **Settings...** panel allows you to change how the elements are plotted. You can set maximum and minimum values for the component and change how elements that fall outside the range are plotted (if you set a maximum or minimum value).

The **Levels...** panel allows you to change how many contour bands are displayed. In the panel on the right 6 bands are chosen.



-0.457535

-0.380478

-0.303421

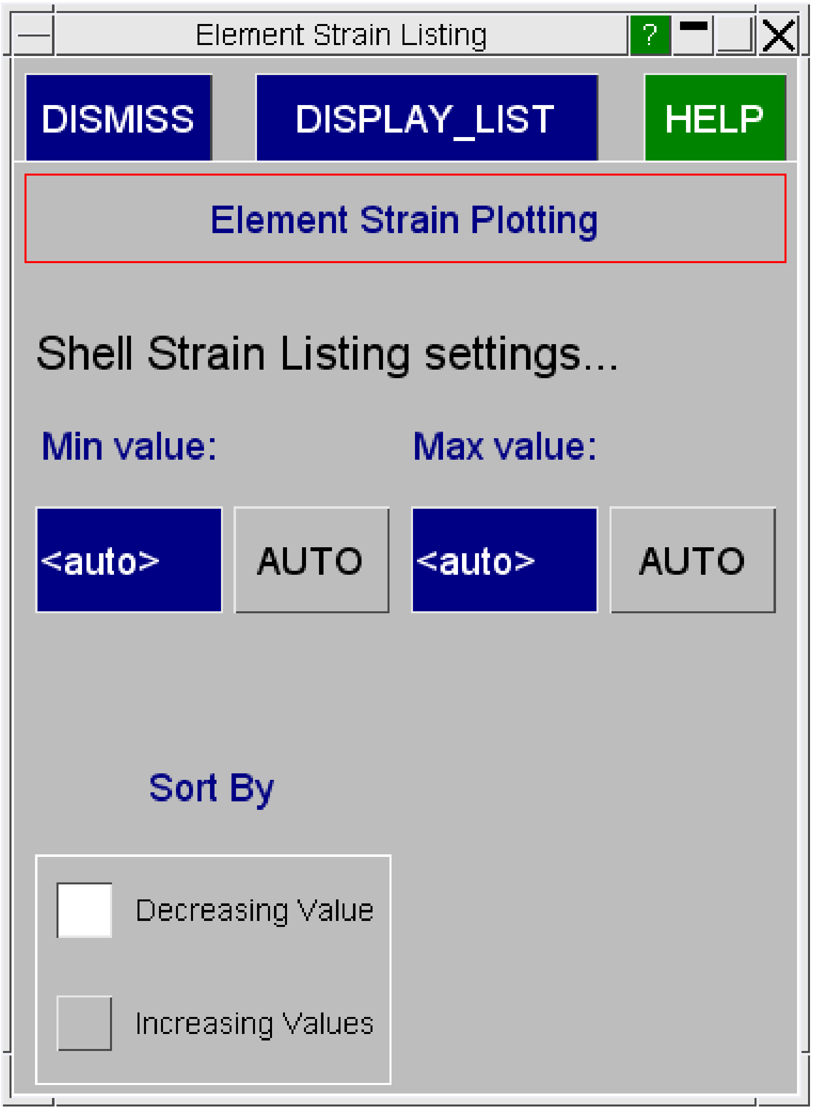
-0.226363

-0.149306

-0.0722491

0.00480813

The **Listings...** panel allows you to print the values to the screen or a file. You can limit the elements to list with a maximum and/or minimum values.



Shell Strain Listing settings...

Min value: <auto> AUTO

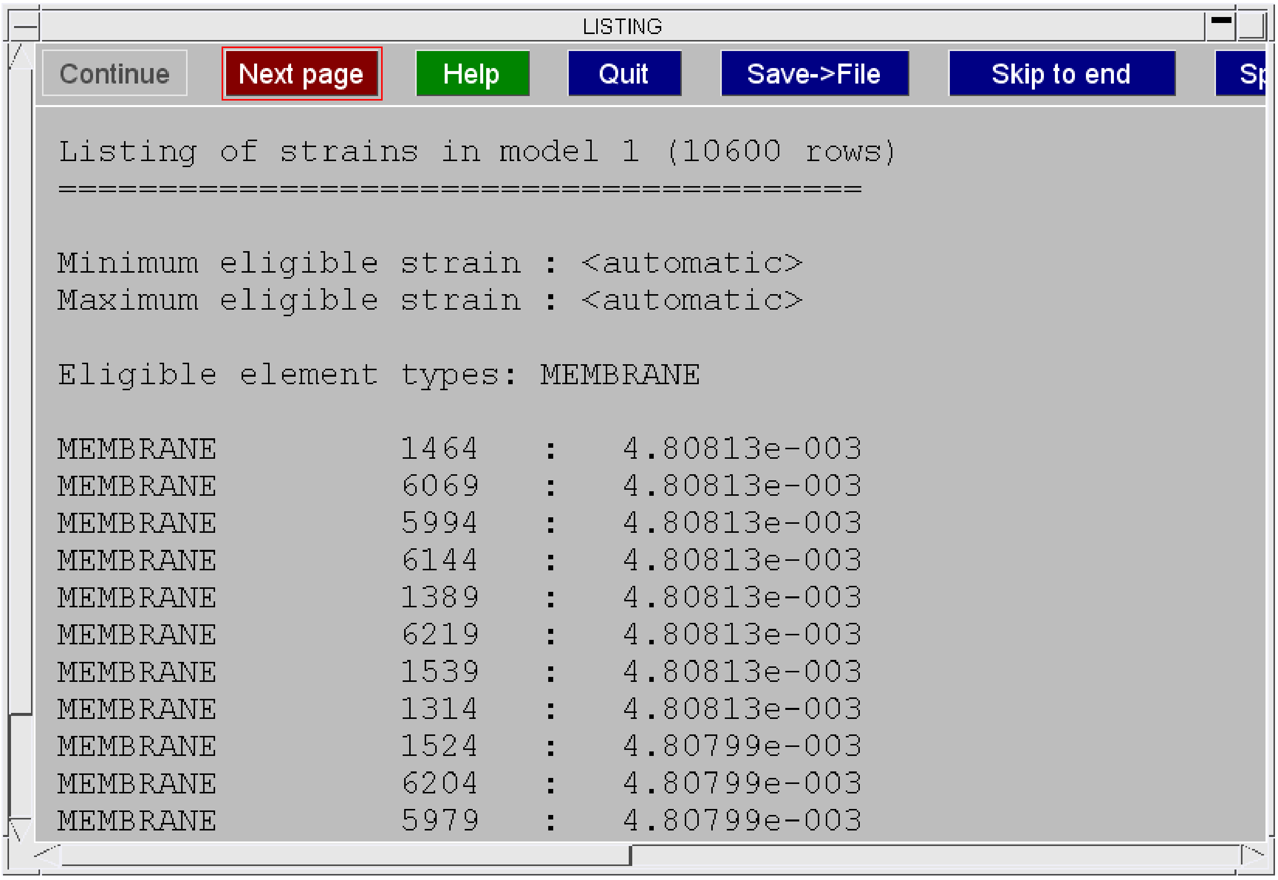
Max value: <auto> AUTO

Sort By

□ Decreasing Value

□ Increasing Values

A **Listing...** of the largest maximum principal strains is shown below. This can be saved to file using the SAVE->FILE button.



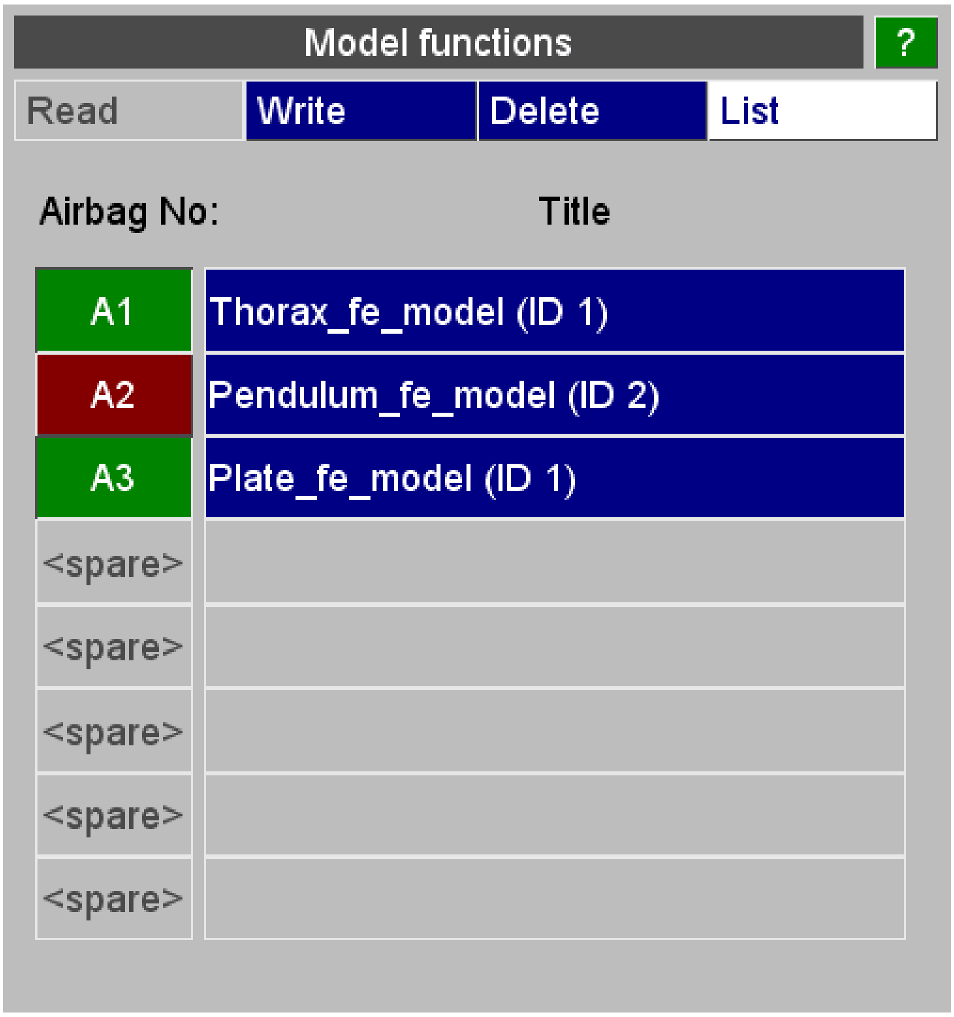
```
Listing of strains in model 1 (10600 rows)
=========================================

Minimum eligible strain : <automatic>
Maximum eligible strain : <automatic>

Eligible element types: MEMBRANE

MEMBRANE         1464   :   4.80813e-003
MEMBRANE         6069   :   4.80813e-003
MEMBRANE         5994   :   4.80813e-003
MEMBRANE         6144   :   4.80813e-003
MEMBRANE         1389   :   4.80813e-003
MEMBRANE         6219   :   4.80813e-003
MEMBRANE         1539   :   4.80813e-003
MEMBRANE         1314   :   4.80813e-003
MEMBRANE         1524   :   4.80799e-003
MEMBRANE         6204   :   4.80799e-003
MEMBRANE         5979   :   4.80799e-003
```

The remaining components that can be contoured in **CT** or **SI** mode are processed in a similar way, although the **Settings...** panel for each varies according to its context.

4.3 Controlling Model Visibility

Models can be enabled or disabled for display at will. This is carried out by setting them to "hidden" or "viewable": hidden airbags will not be drawn by any drawing command. By default an airbag is viewable when it is first read in, but thereafter its visibility is controlled by the user. Changing its status only takes effect the next time a drawing command is given.

Manipulating an airbag's status is simple:



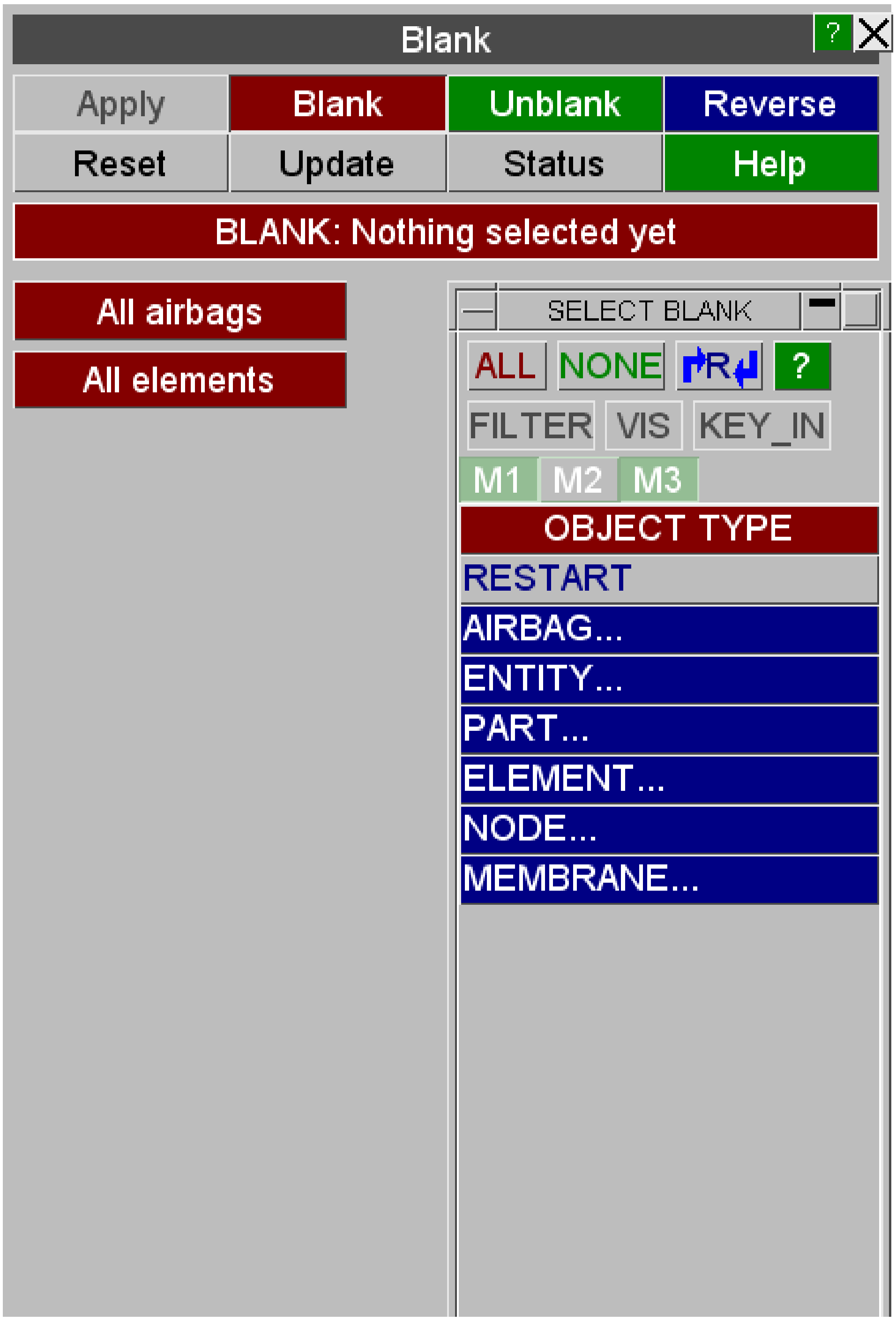
Airbag No:	Title
A1	Thorax_fe_model (ID 1)
A2	Pendulum_fe_model (ID 2)
A3	Plate_fe_model (ID 1)
<spare>	
<spare>	
<spare>	
<spare>	
<spare>	

Under **MODEL** > **LIST** click on the **Annn** buttons in for the relevant models. A depressed button (green) is viewable, undepressed (red) is hidden.

In this example airbags 1 and 3are viewable.

Setting an airbag's visibility in this way has the highest priority when determining whether something should or should not be drawn. If the airbag is not viewable none of its contents will be, regardless of Entity switches or Blanking. However, making an airbag viewable does not cause its contents to be displayed if the entity types are not visible (section 4.4) or if the entities are blanked (section 4.5).

In addition turning off an airbag in the **MODEL** > **LIST** menu has the effect of turning off its "**An**" tab in all selection menus throughout the code. For example given the case above of five models, with A3 and A5 deselected, the **BLANK** panel will start off looking like this:



Note that the M1 and M3 tabs are deselected. You can still turn them on manually if you wish.

In other contexts, for example when creating items, if you only have one airbag "live" in the **MODEL** > **LIST** menu the question "which airbag do you want to create it?" will be omitted, saving one mouse click.

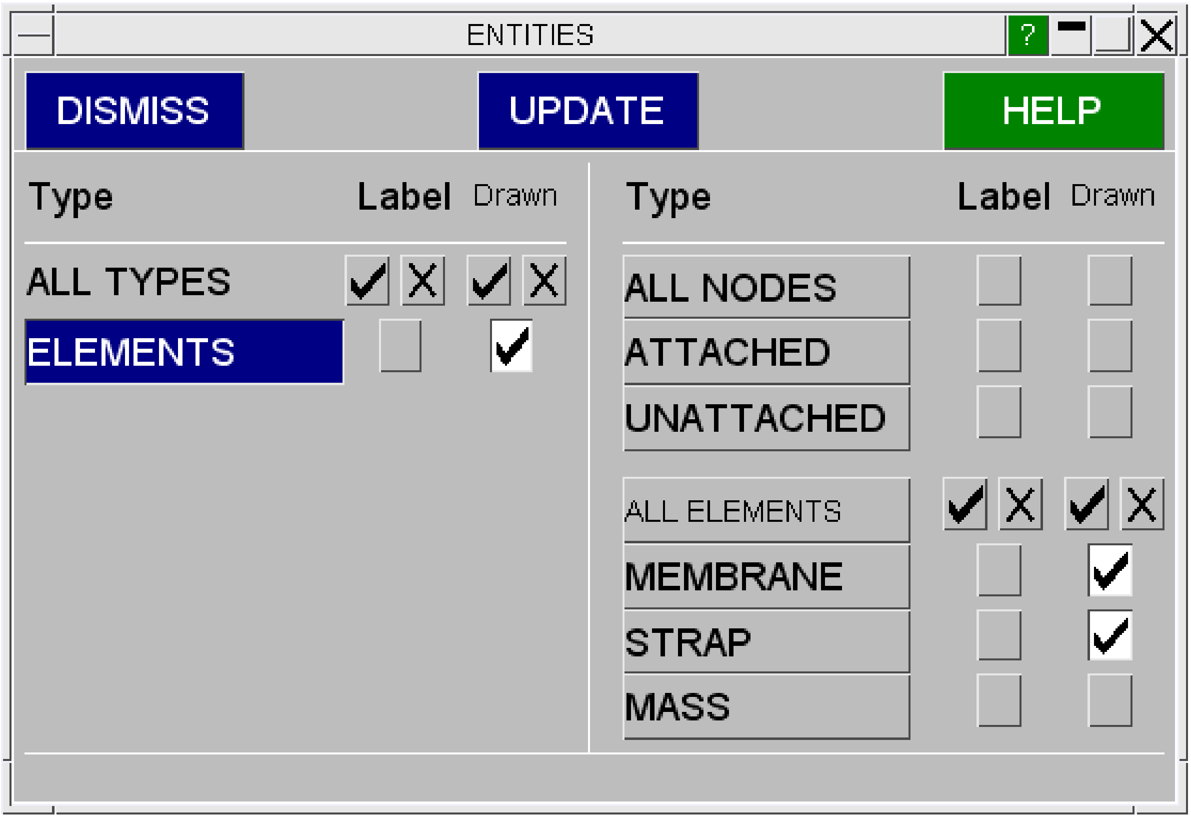
4.4 Controlling Entity visibility and labelling

By default only the elements in a model are drawn, with no labels, node symbols or other information appended to them.

You can add extra information to plots, control the display of classes of information and label items dynamically on the screen using the **ENT**ity Viewing panel. This can be accessed in 4 ways:

1. The keyboard shortcut key **E**.
2. The top bar menu **DISPLAY** > **ENTITIES**
3. The **ENT** from the viewing and drawing window.
4. The **ENTITIES** button in **TOOLS**

This panel controls the display of elements and nodes, (ie basic "structural" items); also their symbols, labels and local direction triads.



It must be stressed that these commands only permit or deny the display of *classes* of information, they do not control the visibility of individual items or models. However they do provide one means of accessing the "dynamic" labelling of items: see section 4.6.

For example they might be used to enable the display of nodes. This would permit nodes in any models to be displayed provided they were not made invisible by some other command.

The left hand column of the panel dictates the display of the right hand column. At any one time the "master" category (**Elements**) will be selected from the left-hand column. The "master" category contains further "child" categories below them. The right hand column displays the appropriate "child" categories for the selected"master". The **Label** columns control whether or not the items will be labelled**.** The **Drawn** columns control whether or not the items will be drawn. "Child"categories can be controlled individually (in the example shown the display of mass has been turned off), or all the child categories may be switched on/off together by switching on/off the master category or the ALL_<*category*> row.

4.4.1 Elements and nodes (Structural Items).

Nodes are treated as a special case:

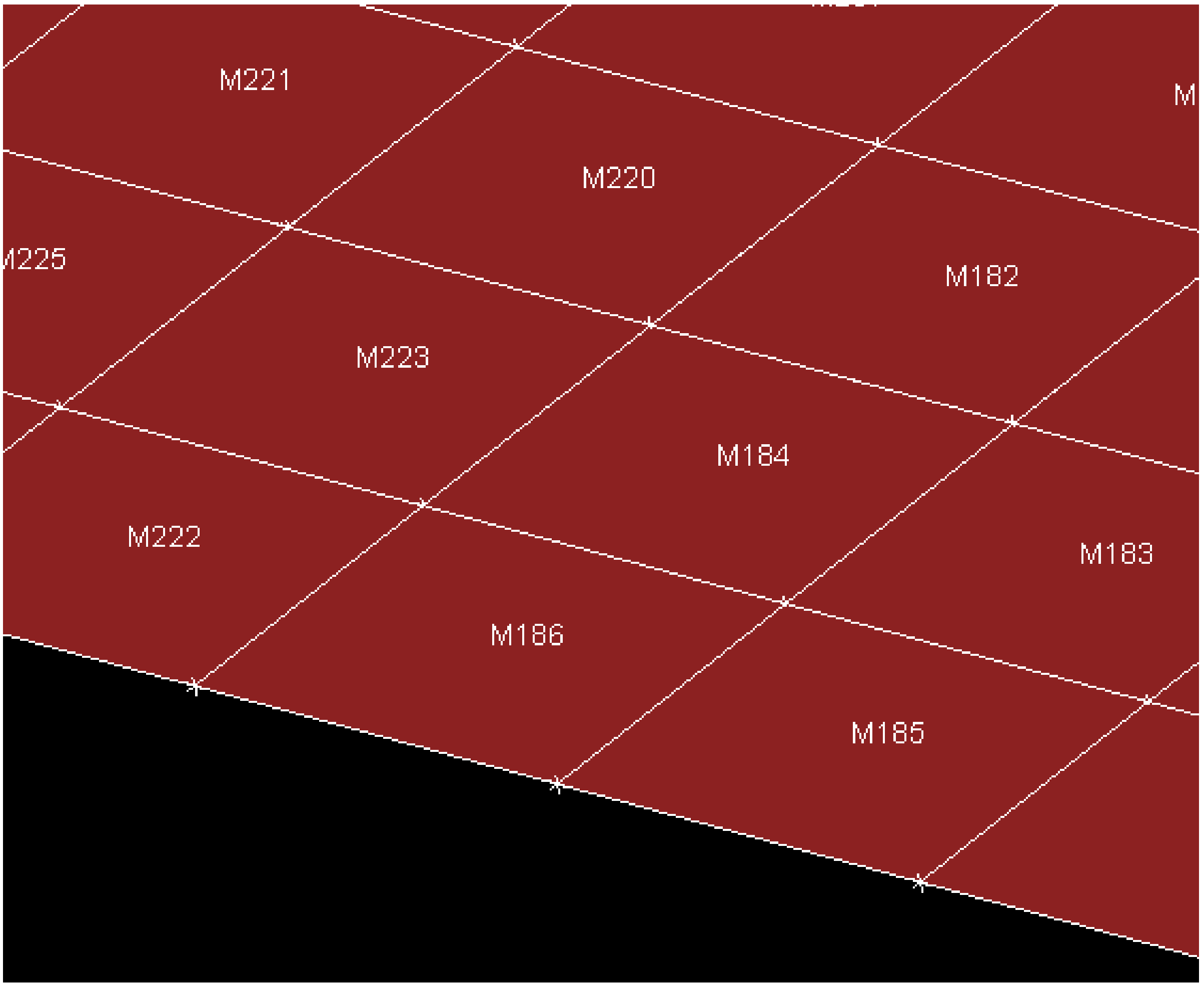
- **ALL NODES** draws all nodes, regardless of attachments.

- **ATTACHED** draws only nodes attached to some other items currently displayed.
- **UNATTACHED** draws only nodes that are not attached to anything (visible or not).

Associated data: Local direction **TRIADS** are drawn for element types with coordinate systems.

4.4.2 How labelling on plots is handled for nodes and elements

The default label is a node or element number, but a variable amount of information can be generated to form a "label" which can run to multiple lines, as this example shows:



This figure shows an example of shells which have been labelled with:

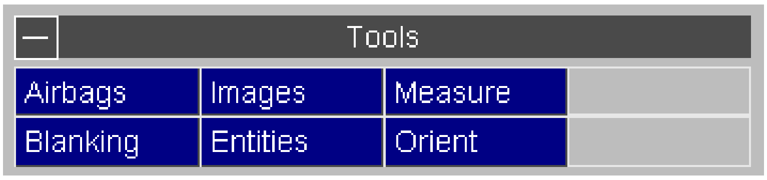
LABEL **Mnnn** for ***M***embrane<nnn>.

FOLDER attempts to group labels logically and to locate them so that they don’t overlap, but if you try to add too much information you will end up with a total mess on the page. For example, two categories of data labelled on elements, is the sensible maximum; and even it starts to get messy when label numbers get large (> 5 digits).

Labelling uses the standard acronyms for entities, these are listed in Appendix 1.

The "attached" nodes in this figure have also been switched on: these are drawn as asterisks (*) at the relevant element vertices.

4.5 BLANKING Controlling entity visibility



Blanking allows the user to cut down what is displayed by controlling whether individual items are marked as drawable or not.

For an item in FOLDER to be drawn it must pass the following three tests:

Is the airbag visible?	=>	Is the entity type drawable?	=>	Is the entity unblanked?
(See section 4.3)		(See section 4.4)		(This section 4.5)

These represent increasingly more detailed levels of testing and the last of these checks, blanking, is performed on a per entity basis. Every drawable entity in FOLDER may be flagged as

- either "***blanked***" (not eligible for drawing)
- or "***unblanked***" (eligible for drawing)

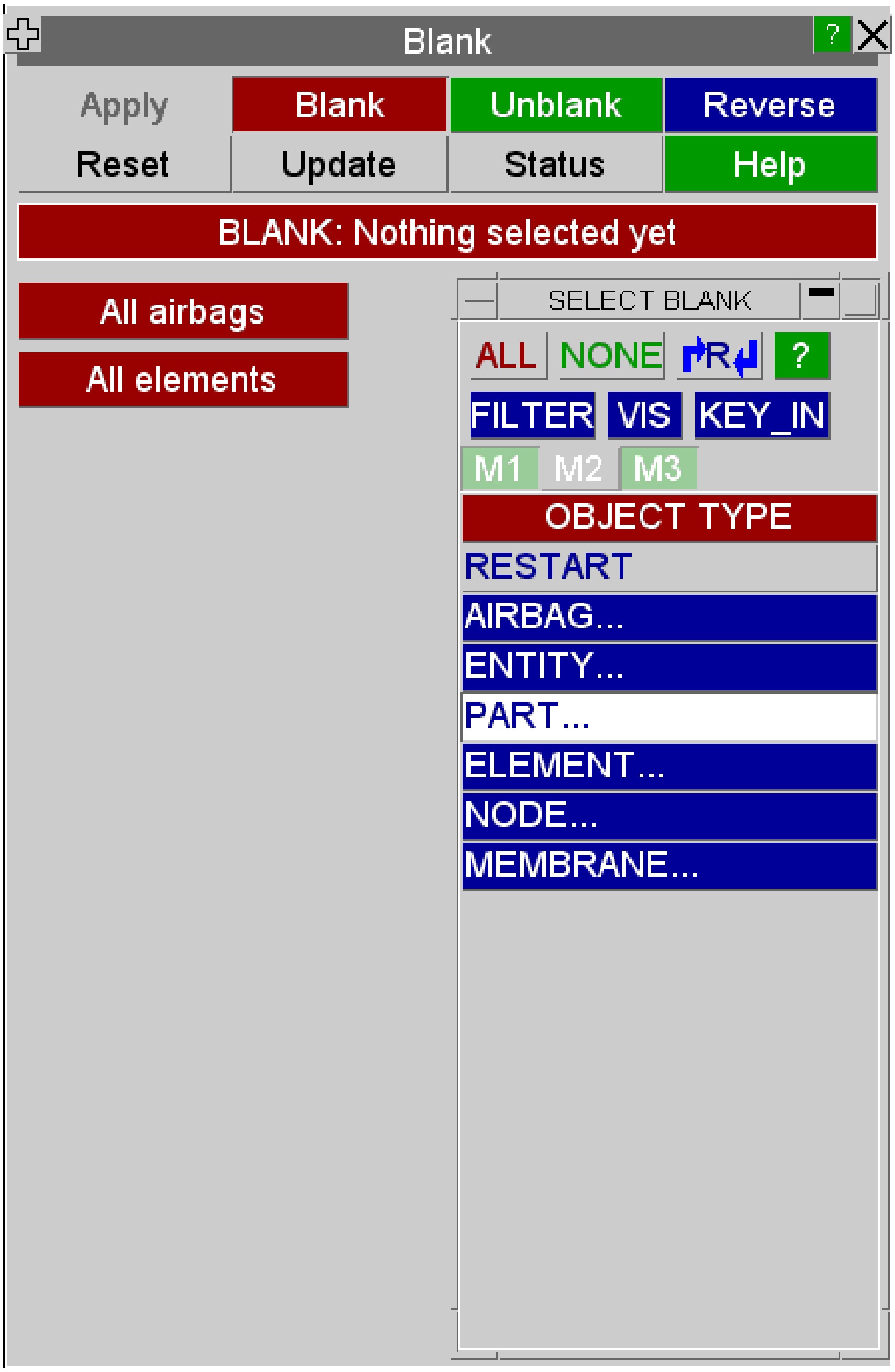
The default being ***unblanked***. Control of the blanking status can be exercised in the standard hierarchical fashion of airbags, sets, parts and finally down to individual items; thus it may be used to control exactly what is seen on the screen.

As well as the main **BLANK** menu described in this section, Blanking may be activated by:

- Keyboard short-cut keys (section 4.5.4 below)
- Special keys in the View panel (section 4.5.5 below) which include "locking".

4.5.0 The BLANK menu

This figure shows the main **BLANKING** Menu:



It has three colour-coded states:

BLANK	(Red) makes the selected entities invisible.
UNBLANK	(Green) makes the selected entities visible again.
REVERSE	(Blue) inverts the status of the selected entities.

To use it: select a list of items, choose one of the three states above, and press **APPLY**.

The effect will be seen the next time the image is drawn, or when **UPDATE** is used.

The **ALL_xx** commands are to provide short cuts for commonly issued commands:

ALL_AIRBAGS Means ***everything***! All the contents of all airbags currently in memory will be operated on.

ALL_ELEMENTS Means all elements (of all types) in all models.

These short cut commands will operate faster than the equivalent commands from the **SELECT** menu since they don’t have to perform the hierarchy propagation checks implicit in using the menu.

RESET Resets to null the contents of the **SELECT** menu. This may be used to delete any current selection and start again.

UPDATE Redraws the current image following a blanking change. This is necessary to see the effect of any changes (unless the Update Level in the View Control box has been set to "frequent", in which case changes take effect immediately).

4.5.4 Blanking control using keyboard shortcut keys

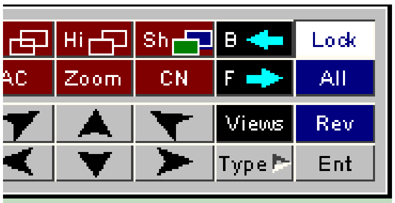
The following keyboard "short cut" keys influence blanking:

U (**nblank all**) Unblanks everything, ***unconditionally***, subject to "locking" (see below)

R (**everse all**) Reverses the blanking status of everything, using the current **Recursive Action** logic.

4.5.5 "Locking" blanking in the "View" panel.

Blanking may also be "locked" to its current status via the following buttons in the View panel:



Lock "locks" the current blanking status so that keyboard short cut **U**(**nblank all**) returns to the "locked" visibility status. The Lock button toggles on / off.

All is exactly the same as keyboard shortcut **U**(**nblank all**) above

Rev is exactly the same as keyboard shortcut **R**(**everse all**) above

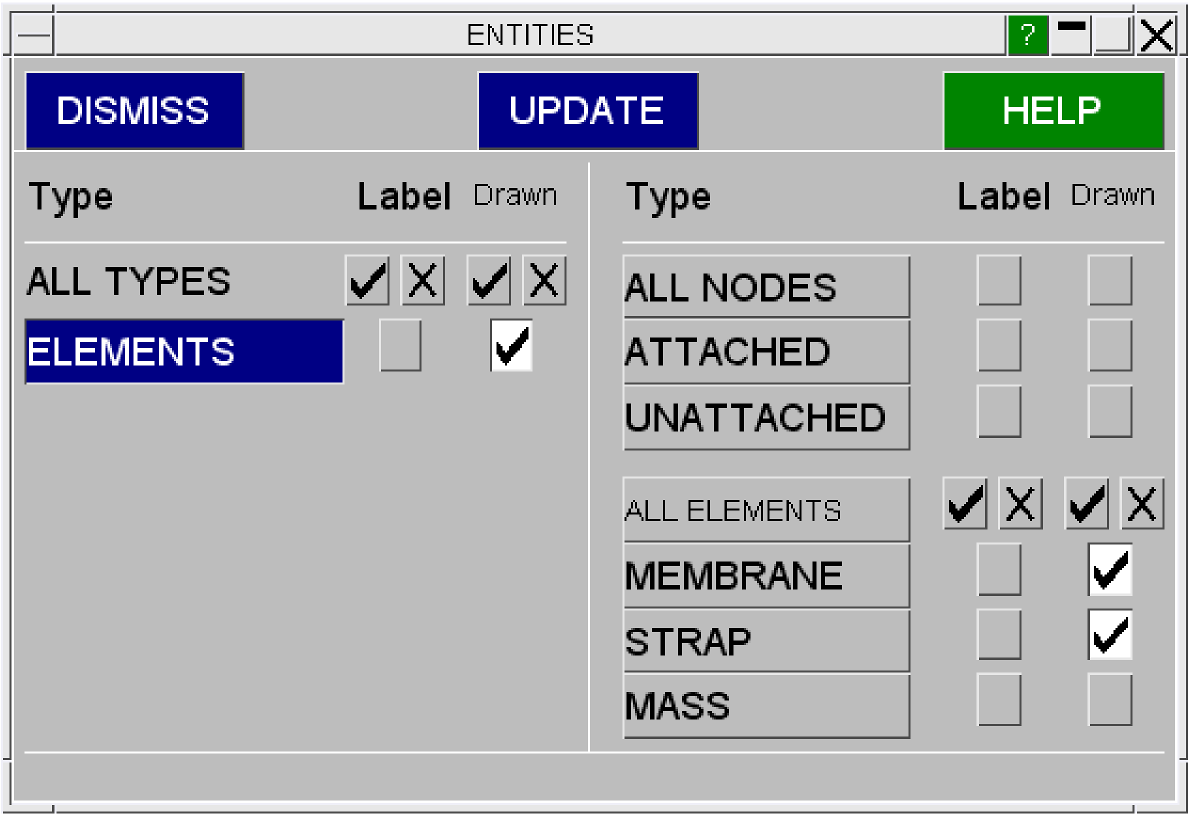
The purpose of "locked" blanking is to allow the user to return easily to a previous image.

"Locking" does ***not*** affect blanking carried out by the main Blank Panel, Quick Pick blanking, or blanking from the Part Tree.

4.6 Dynamic Labelling

Sketching labels and associated information on the existing plot.

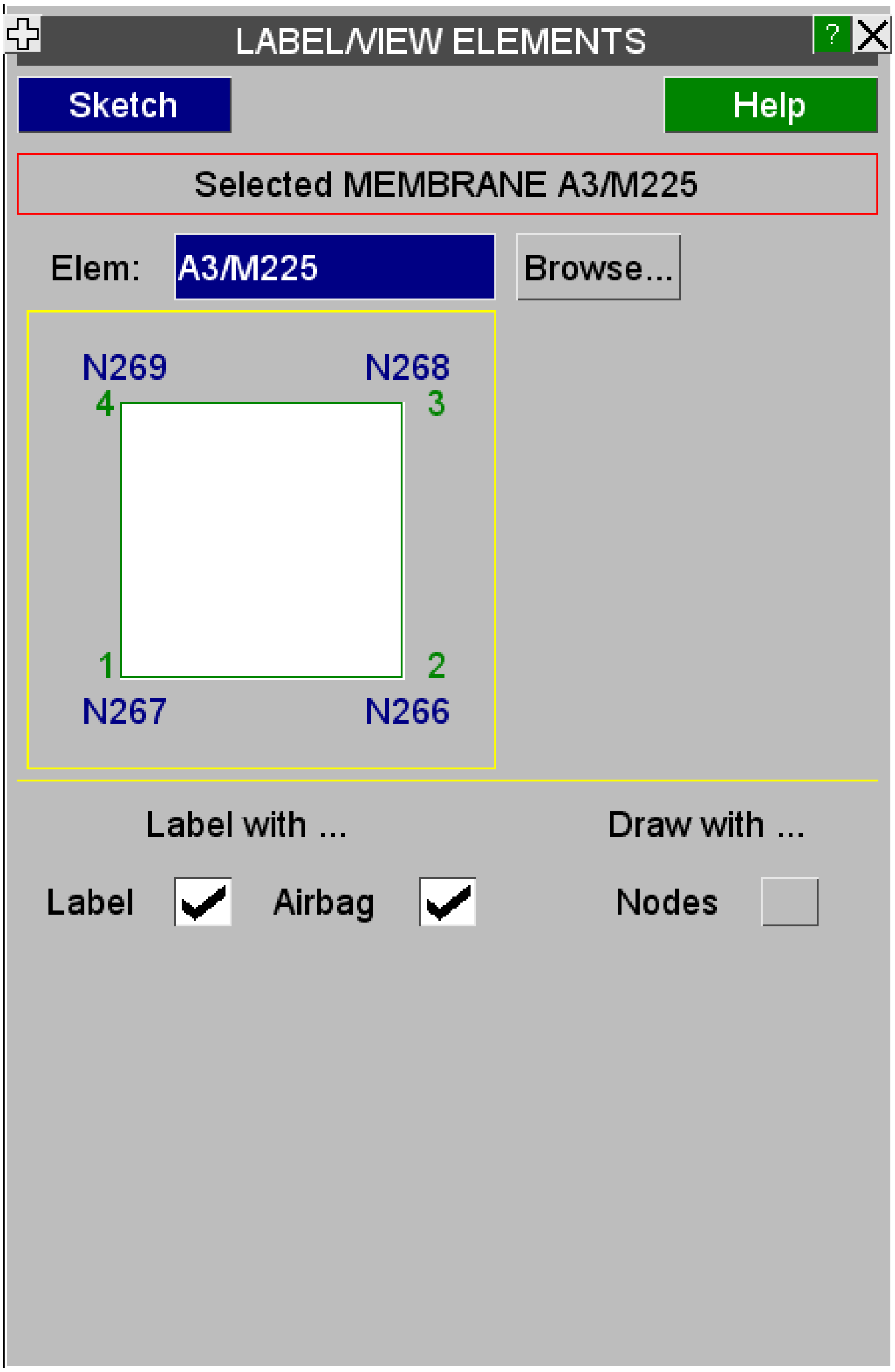
4.6.1 Using the "type" Element and Node buttons in the Entities panel



In section 4.4 above the use of the ENTity Viewing panel to control labelling on plots was described.

It is also possible to label nodes and elements "dynamically", which means "instantly on the existing image".

- Select**ELEMENTS** from the left hand "type" column
- Select a category from the right hand "type" column .
- This maps the labelling panel for that item type (below).
- Click on items of that type to label them immediately.



Selected MEMBRANE A3/M225

Elem: A3/M225

Label ☑ Airbag ☑ Nodes □

This figure shows a typical dynamic labelling box for membrane elements.

It is updated automatically as you click on elements, or you can type a new element number into the **Elem:** box.

More than one airbag is current in this example, so typed in elements must be prefixed with their airbag id. In this example membrane element 25468 in airbag #3 (**A3/M225**) has been selected.

Not only is the element in question labelled on the screen, but its major attributes are presented in this panel:

- The nodes on the element are drawn schematically. (Note that the schematic shape is idealised, here as a square, not the true shape of the element.)

The "**Label with ...**" buttons control how the selected items are labelled on the screen. The categories are the same as those in the main **ENT**ity Viewing panel, but apply only to these "dynamically" labelled items.

The "**Draw with ...**" buttons control what extra information is added to the selected items:

Nodes Adds the labels of nodes connected to this element

Selection will be limited to the class of item selected in the **ENT**ity Viewing panel. However selecting class **ALL_ELEMENTS** permits any class of element to be selected for labelling.

The details of this **LABEL/VIEW** panel will vary with the class of object being shown: for example the panel for nodes doesn’t show a diagram but rather lists coordinates, etc for the node.

This panel can also be invoked anywhere in FOLDER from popup windows offering the **LABEL/VIEW** option

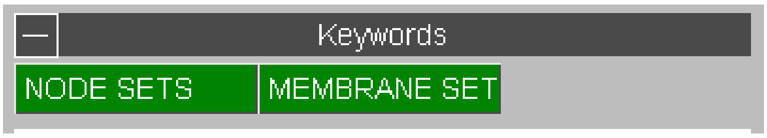
5 Keywords

Master Index

Oasys

5.0 Keywords

FOLDER allows you to create, modify, list and delete the constituent parts of an input deck, and this is done by object category, ie "Keyword".



Keywords are chosen from the **KEYWORDS** menu which contains all major keywords. Once an item has been selected the top-level menu panel for that item will be invoked: see section 5.0.1 below.

There is no limit to the number of different keyword manipulation windows that can be current at any time: for example you can edit concurrently as many NODE SETs as you like.

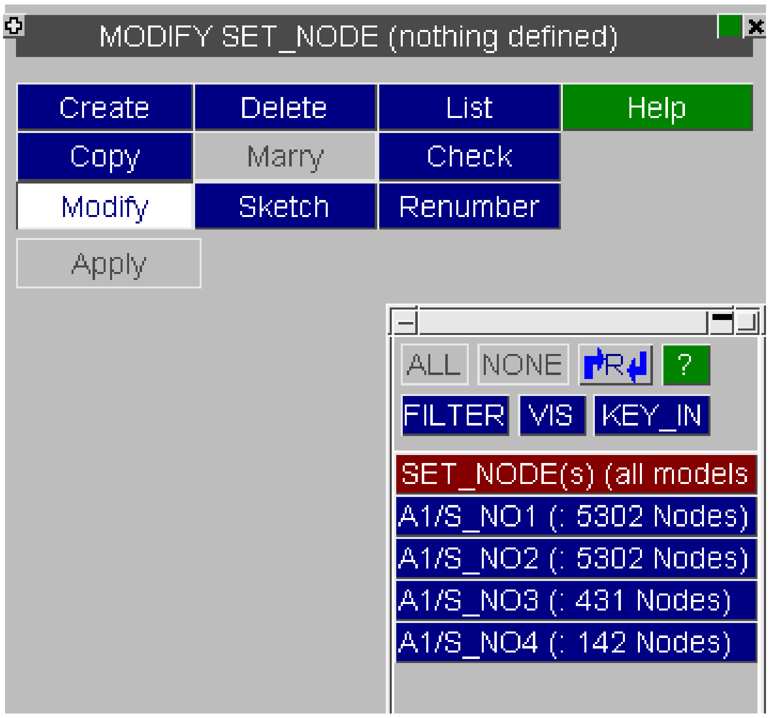
Keywords present in the MADYMO manual but not in FOLDER’s Keyword panel cannot be viewed or edited in FOLDER. However, they are stored in temporary ’scratch’ files, so no valid MADYMO data is lost.

5.0.1 Standard Keyword top level menu options.

Most of the **KEYWORD** options have a set of standard options. The exact contents may vary slightly with context, but the basic functionality is the same in all cases.

This figure shows a standard display, here for **ELEMENT_SOLID** keywords, but it is the same for any item type. Currently Modify is the selected option. Selecting any of the other buttons will switch to that option.
These "standard operations" options are:

CREATE	Create a new item
COPY	Copy existing items
MODIFY	Edit (modify) an existing item.
DELETE	Delete one or more existing items.
SKETCH	Sketch existing items on top of the current image.
LIST	List a summary of the contents of existing items.
CHECK	Check items for errors.
RENUMBER	Change the labels of items.

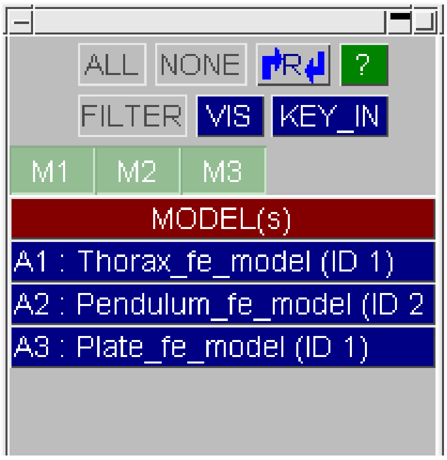


Not all options will be available in all contexts, for example **CREATE** and **MODIFY** will not be available where specific editing/creation functions do not yet exist in FOLDER.

Operations requiring an explicit "Parent" airbag id.
If you have more than one airbag in memory, and the operation in question requires an explicit "parent" airbag id, then you will be forced to select an airbag prior to the operation taking place.

For example when you **CREATE** an element it must exist in one airbag only so, in the multiple airbag case, you will be asked to select which airbag to use.

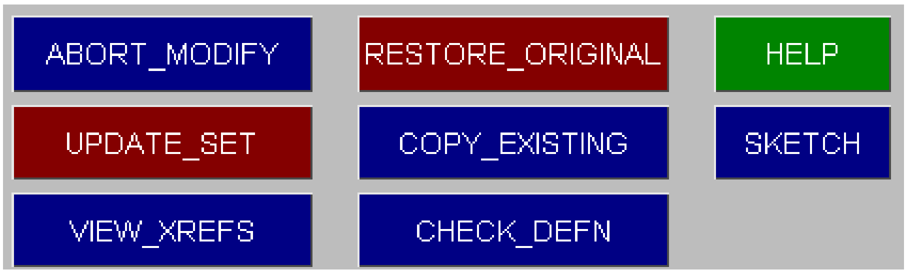
If only one model is current it will be used automatically and this selection stage will be skipped


ALL
NONE
R
?
FILTER
VIS
KEY_IN
M1
M2
M3
MODEL(s)
A1 : Thorax_fe_model (ID 1)
A2 : Pendulum_fe_model (ID 2
A3 : Plate_fe_model (ID 1)

5.0.2 Standard "static" header for CREATE and EDIT functions

The Create/Edit panels for Keywords differ in detail, but share a common layout of the "static" functions at their top.

This example is taken from a Set Node editing panel, but the top buttons are the same in all cases.



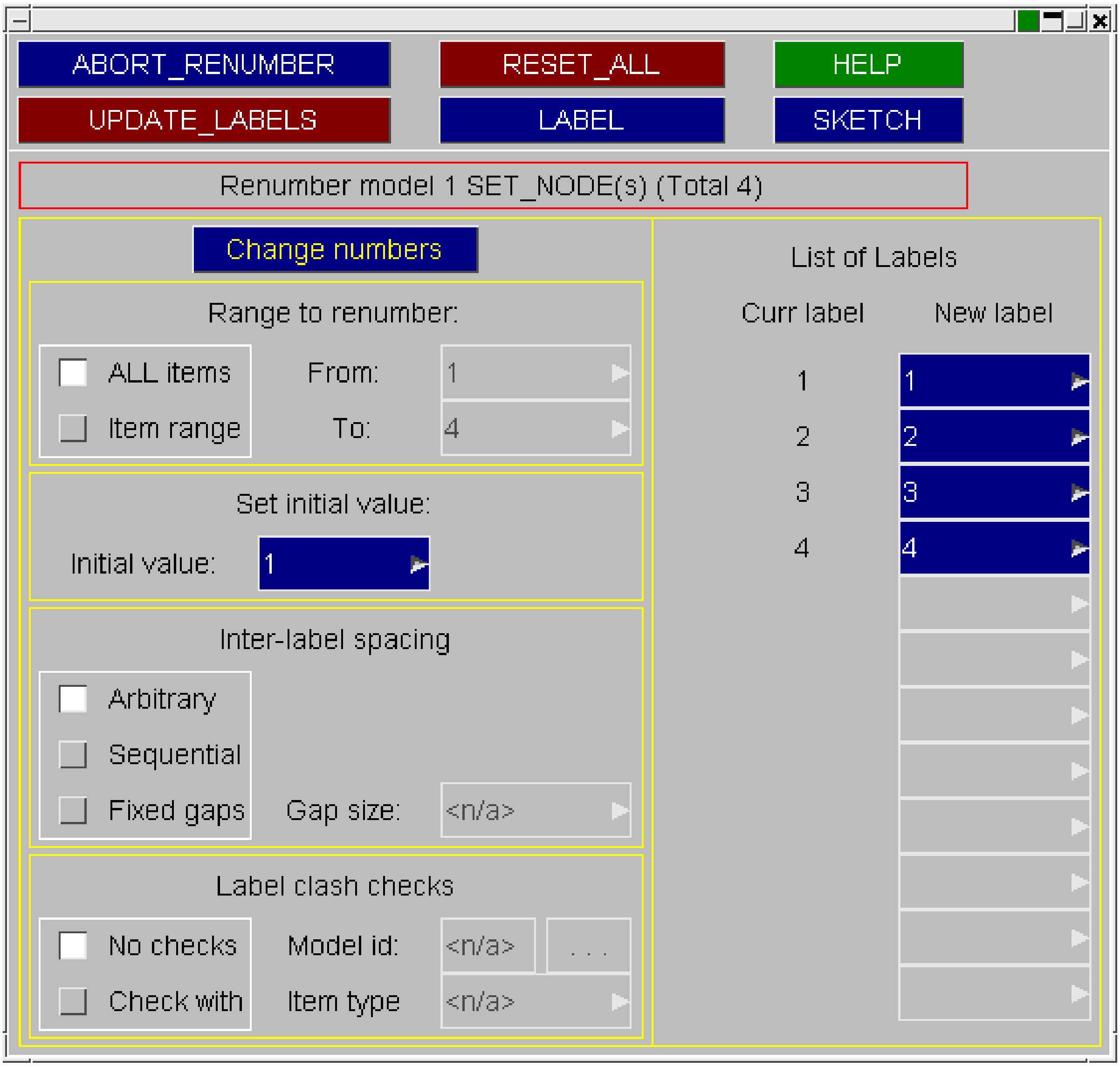
The standard buttons act as follows. Note that some have vary between "Create" and "Edit" modes, whereas others are common to "Both":

ABORT_item	(Both)	Terminates the current operation, leaving the permanent definition unchanged (edit case) or undefined (create case).
RESET_ALL **RESTORE_ORIGINAL**	(Create) (Edit)	Resets the definition to null, canceling any entries made so far. Restores the original, unedited definition (copied from the permanent definition), overwriting any changes made so far.
CREATE_item **UPDATE_item**	(Create) (Edit)	Creates a permanent entry from the scratch definition. Overwrites the "old" permanent definition with the revised entries from the scratch definition.
COPY_EXISTING	(Both)	Copies entries from an existing definition into this one, superseding any entries or changes made so far.
SKETCH	(Both)	Sketches the currently defined scratch definition on top of the current graphics image.
CHECK_DEFN	(Both)	Checks the current scratch definition for errors

Remember: All Create and Edit functions ***always*** take place on a "scratch" copy of the current definition (if any). No changes are made to the permanent database until the **CREATE** or **UPDATE** buttons are used.

5.0.3 Standard category renumbering panel.

Wherever a **RENUMBER** option is available for an item category this will invoke the standard renumbering panel for that item



Renumber model 1 SET_NODE(s) (Total 4)

Range to renumber:

□ ALL items From: 1

□ Item range To: 4

Set initial value:

Initial value: 1

Inter-label spacing

□ Arbitrary

□ Sequential

□ Fixed gaps Gap size: <n/a>

Label clash checks

□ No checks Model id: <n/a> . . .

□ Check with Item type <n/a>

Curr label	New label
1	1
2	2
3	3
4	4

5.1 FOLDER Keywords

***SET**	**Set processing of Node, etc types**

Master Index
Section 5 Index

SET: Defining Sets.

Top level menu
Create
Copy
Edit
Delete

Visualisation

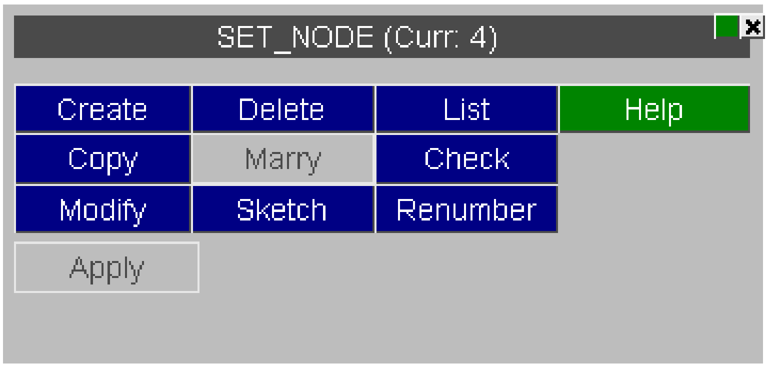
The ***SET** keyword is used to define groups of items that can be used in many different contexts. Valid set types are:

SET_MEMBRANE
_NODE

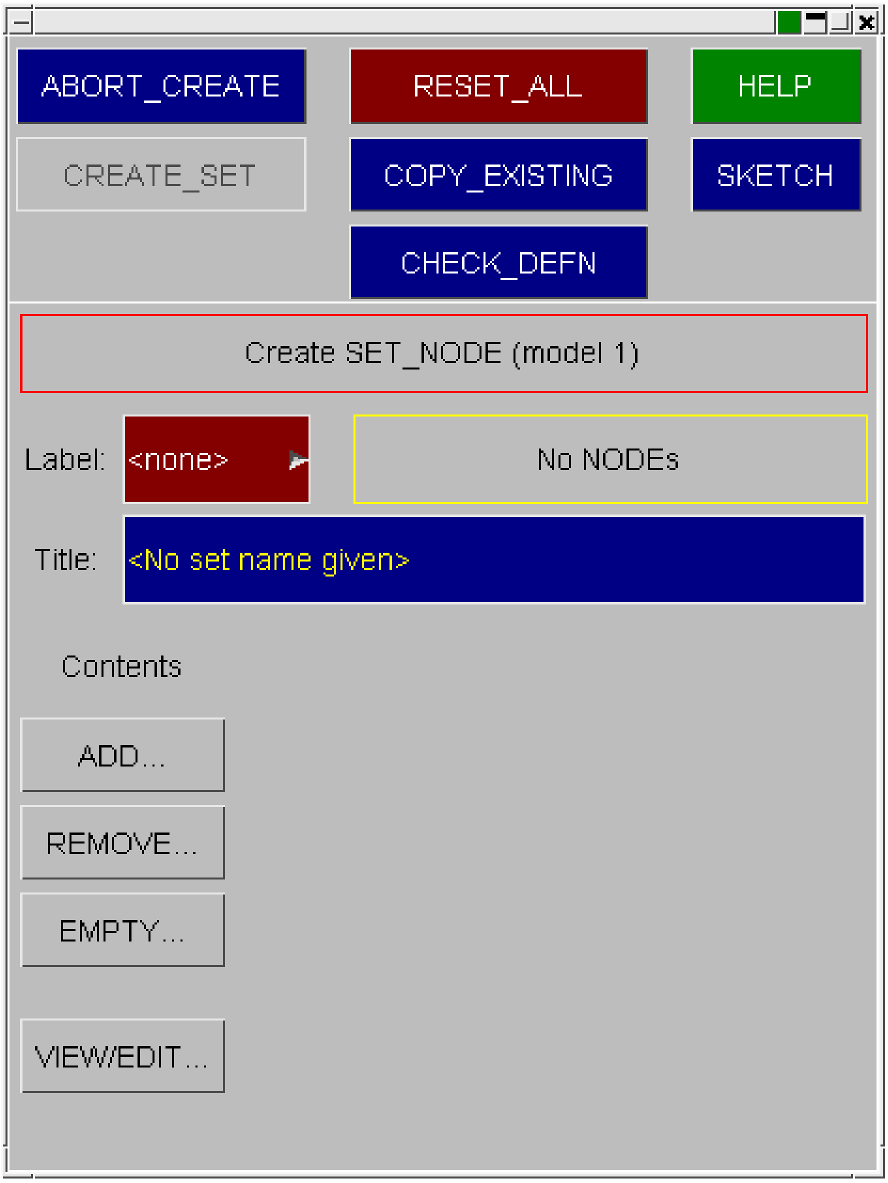
Each set type has its own numbering sequence, thus you can safely have ***SET_NODE #1**, ***SET_MEMBRANE #1,** etc.

This figure shows the common top-level menu for all set types
The figure below shows a typical set main control panel, in this case for **SET_PART** definitions, but all are the same.

Commands have their standard meanings as described in section 5.0.1.



CREATE Creating a new set



Create SET_NODE (model 1)

Label: <none>

No NODEs

Title: <No set name given>

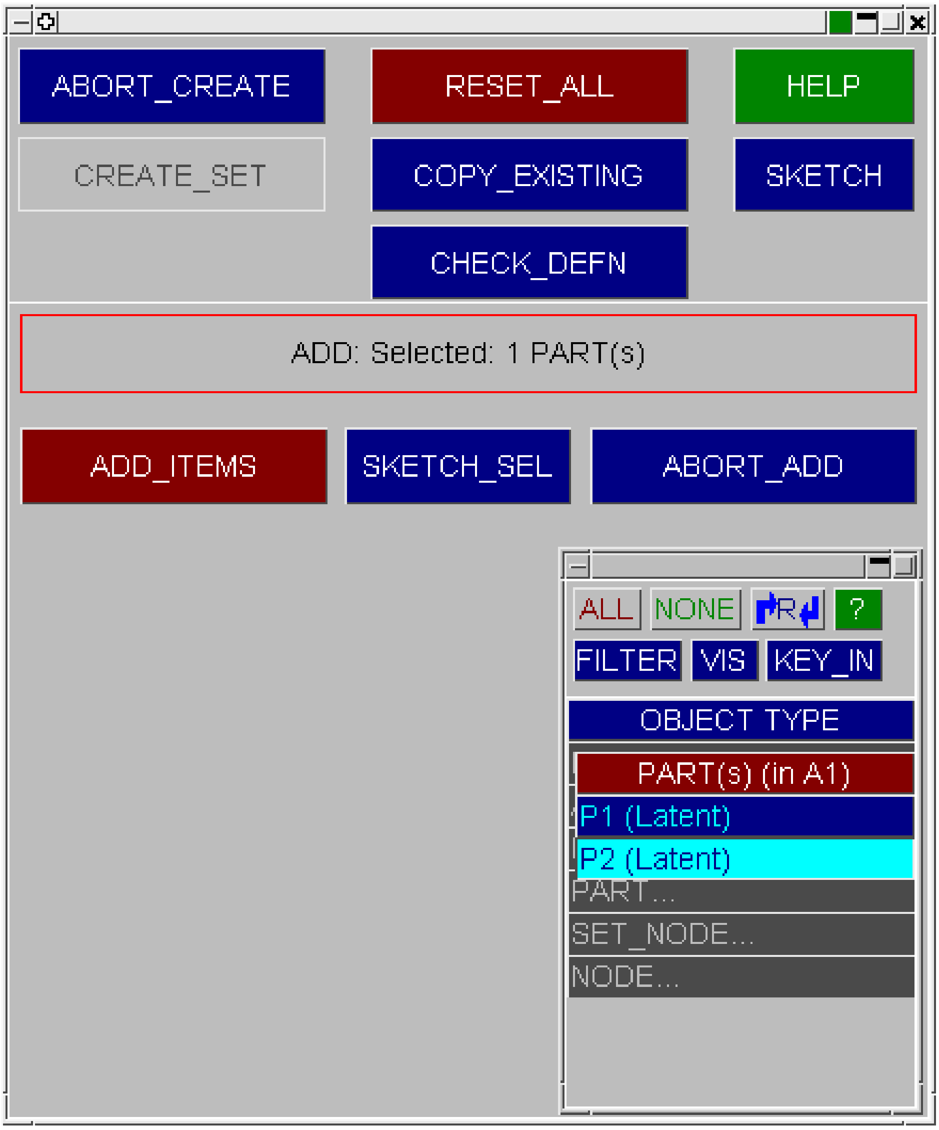
This figure shows the initial empty set creation panel. Items, here **NODEs**, but the same applies to all valid set types, can be added to or removed from the set using:

ADD... Inserts items into the set.

REMOVE... Removes them from the set.

EMPTY... Completely empty the set of all its contents.

Items are added or removed using the standard selection menu, as shown in figure below.



ADD: Selected: 1 PART(s)

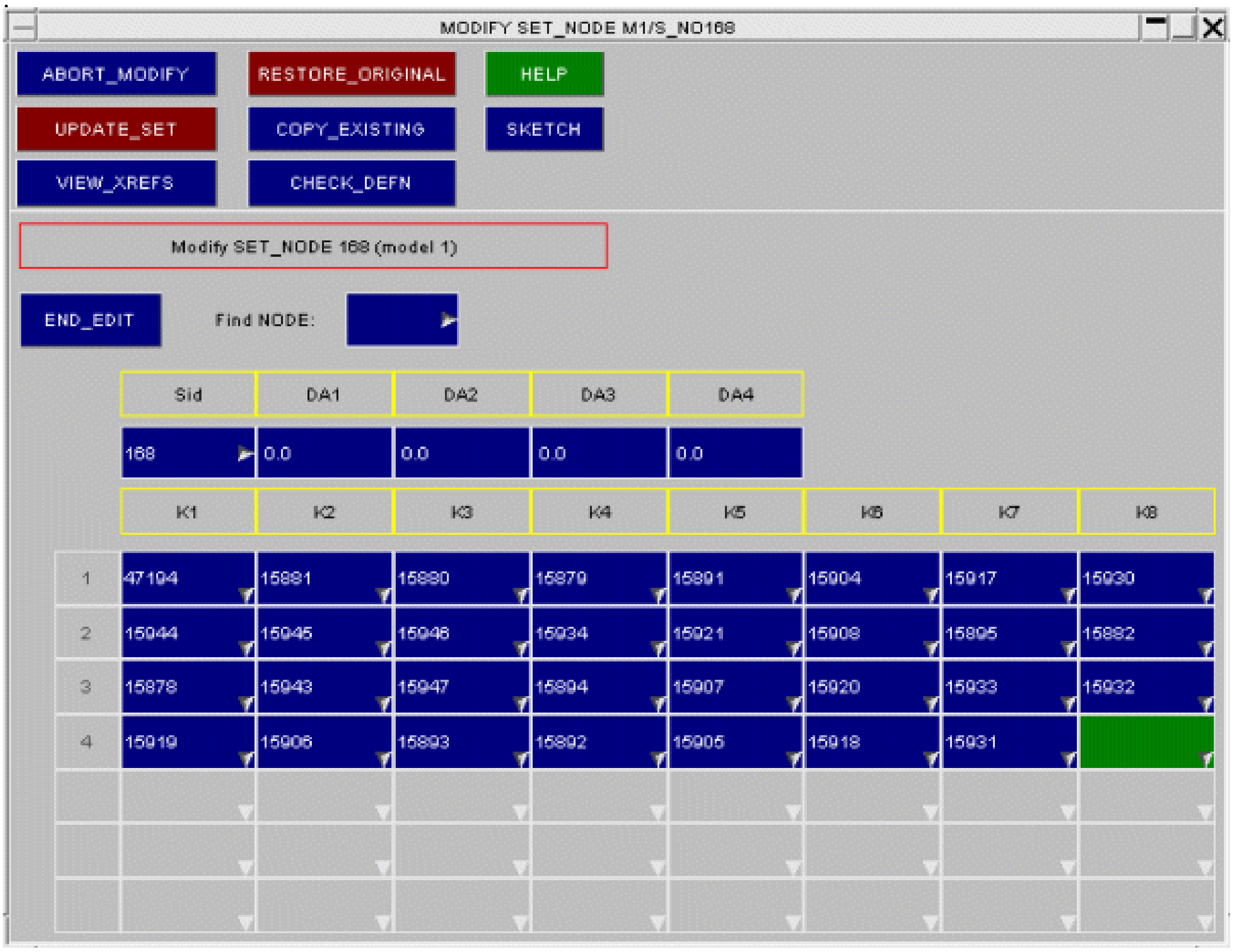
In this example the user is selecting nodes by part: he has selected one part and **ADD_ITEMS** will load the nodes which reference that into the set.
Only items of the correct type, here nodes, will be selected, therefore it is safe to select a super set of the objects required.

For example to load all nodes in a model into a set you could just select the whole model.

It is legal to select items that are already in the set: they will not be duplicated as the addition operation performs a logical (inclusive) OR between the incoming items and the existing set contents.

Item removal operates in exactly the same way, except in reverse.

Once the set contains something you can use **VIEW/EDIT** to view the detailed contents of the set



Modify SET_NODE 168 (model 1)

Sid	DA1	DA2	DA3	DA4
168	0.0	0.0	0.0	0.0

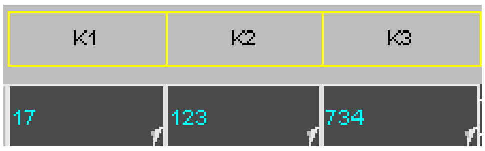
	K1	K2	K3	K4	K5	K6	K7	K8
1	47104	15881	15880	15879	15891	15904	15917	15930
2	15944	15945	15946	15934	15921	15908	15895	15882
3	15878	15943	15947	15894	15907	15920	15933	15932
4	15919	15906	15893	15892	15905	15918	15931	

This example shows the **VIEW/EDIT** panel for a set of nodes.

The popup options against each entry may be used to view details of that item, and different labels can be typed in to change the set's contents.

Defining "Latent" items in a set.

If a "latent" (referenced, but not yet defined) item is included in a set, its colour in the editing table changes to blue text on a dark background to warn you, as shown here.



K1	K2	K3
17	123	734

Including latent items in sets is legal, although they will show as an error when the set is checked. You must deal with this before running the analysis: by deleting them explicitly from the set

COPY Copying sets.

The selected sets are copied. The **RECURSIVE_COPY** flag has an important influence on this:

- When **OFF** Only the set itself is copied. A new set referencing all the items in the original set is created.
- When **ON** All the items "owned" by the set are recursively marked for copying. This can select a considerable number of items: use with care.

MODIFY Modifying sets

The set modification panel is identical to the **CREATE** one, except that it will already be populated when entered, and usage is exactly the same.

DELETE Deleting sets

The selected sets, and possibly their contents, are marked for deletion. What is actually deleted, and whether deletion of the set actually takes place, depends on the following switches:

DELETE_RECURSIVE Whether or not items "owned" by sets are marked for deletion.

- When **OFF** Only the set itself is so marked, its contents are not affected.
- When **ON** The contents, and anything they "own" are also marked for deletion.

REMOVE_FROM_SETS Whether flagged items can be removed from other sets.

- When **OFF** Items (marked recursively) will not be deleted if they are referred to by other sets. (But that won’t stop this set being deleted.)
- When **ON** Items will be removed from any other sets in which they are referred to.

Deletion can only take place if the items referred to are not referenced elsewhere in the model. So deleting a set may fail if it is still in use somewhere, even though its contents may have been deleted leaving it empty!

SKETCH Sketching sets

The selected sets will be sketched on the current graphics image. Sketching is performed by drawing the constituents of a set.

LIST Listing set summaries

A summary of the selected sets is listed to the screen.

CHECK Check sets for errors

The selected sets are processed through the standard checking routines, and the results summarised to the screen.

RENUMBER Renumber set labels

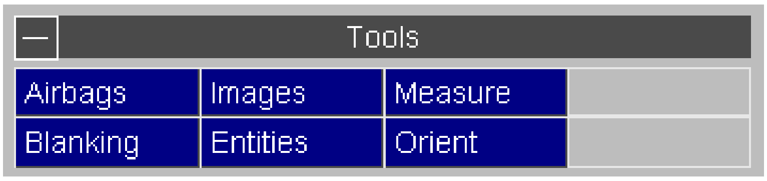
The standard item renumbering panel is mapped for the chosen model, and any or all labels can be changed. To change a single set label it may be easier just to **MODIFY** it.

Visualising Sets.

Sets are not drawn explicitly, rather they are displayed by drawing their constituent parts, elements, nodes and segments. They may be **SKETCH**ed via the commands above, and in most contexts within FOLDER where sets are used it is possible to sketch them via their "daisy chain" popup menus.

6 Tools

This section describes the operations available in FOLDER to manipulate data.



Master Index

6.0 TOOLS

Operations and selecting entities

6.0.1 Operational hierarchy.

6.0.2 Selecting entities

Select selection below for more details

Airbags	Blanking	Measure	Orient

6.0.1 Operational Hierarchy.

Section 6 index
Master Index

Operations in FOLDER act internally using a "hierarchy" of entity types, and it is important that you appreciate how this is applied. A cut down summary of this internal hierarchy is:

Highest level		===>		Lowest level
AIRBAGS	SETS	PARTS	ELEMENTS	NODES

When you select an object for operations it implicitly selects all entities below its level, but not those at or above its own level.

For example selecting an airbag has the effect of operating on everything in that airbag, while selecting a **SET** in that airbag acts as follows:

- The **SET** selects **PARTs**, **ELEMENTs**, etc that refer to it;
- The **ELEMENTs** select **NODEs** on them;

6.0.2 Selecting Entities for Operations.

Section 6 index
Master index

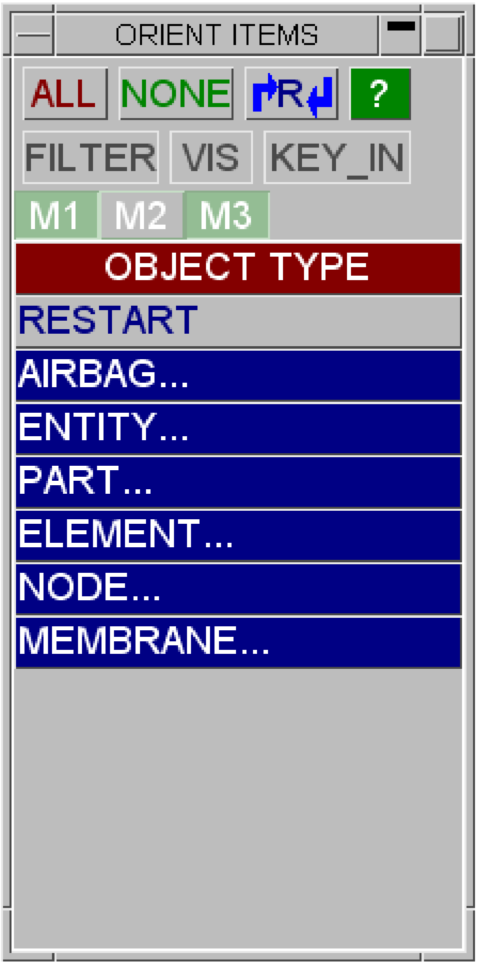
In many contexts within FOLDER (blanking, orienting, deletion, ...) it is necessary to select one or more entities for the current operation. Selection takes place using a system of cascading "object menus", combined with screen-picking, area selection and keyed in data.

When performing operations you have to select those entities upon which to operate. This is done via a standard selection menu hierarchy as follows:

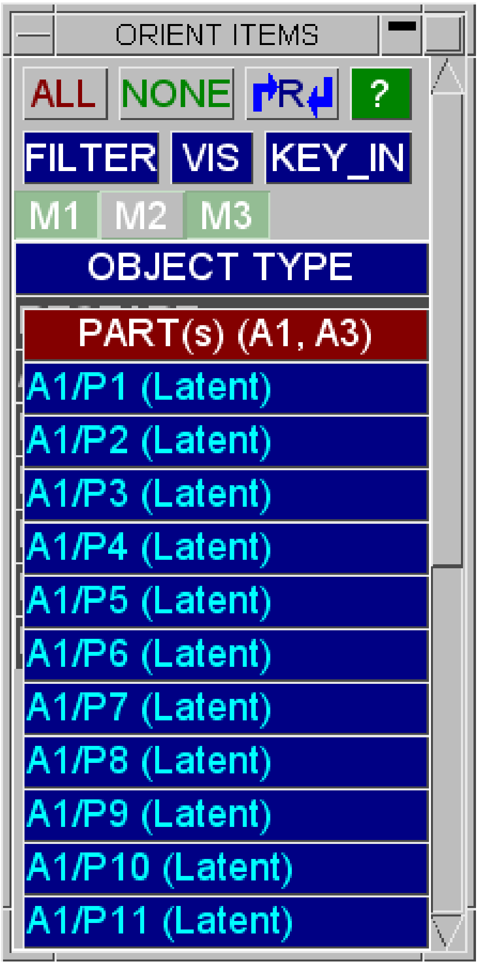
Primary selection of object type

In whatever context you are operating, here **ORIENT**, you will be presented with the primary menu of object types to operate upon.

The list of categories available will depend on the operation being carried out, its context and airbag contents.



Selection of objects from the menu list

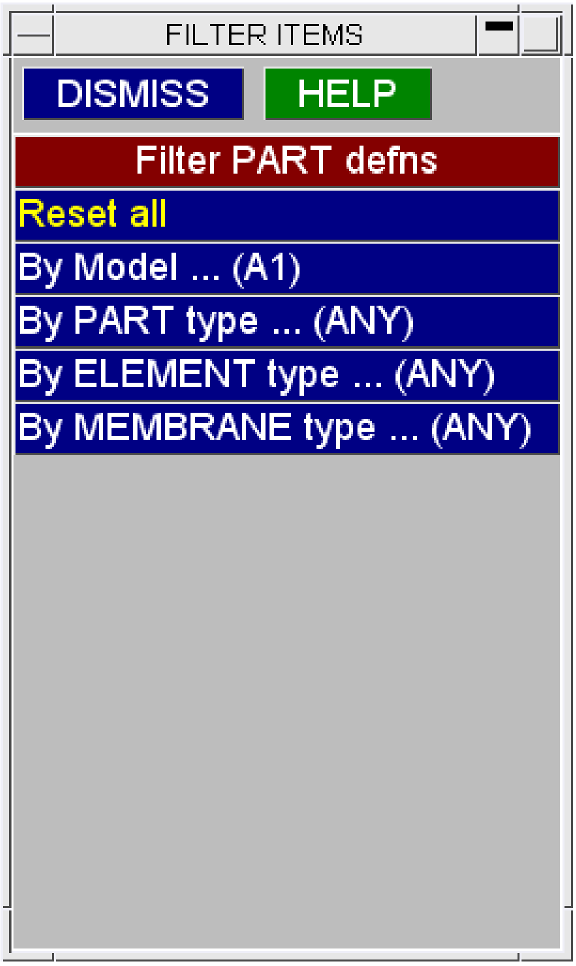


Once an object category has been selected you are presented with a list of possible choices. In this case there are two airbags, each with several parts.

Objects can be selected or deselected (by clicking on them again) at will.

You can select all the objects shown with **ALL**, or deselect them all with **NONE**. Note that **ALL** & **NONE** ***only (de-)select what is shown in the menu*** - for reasons that will become apparent below.

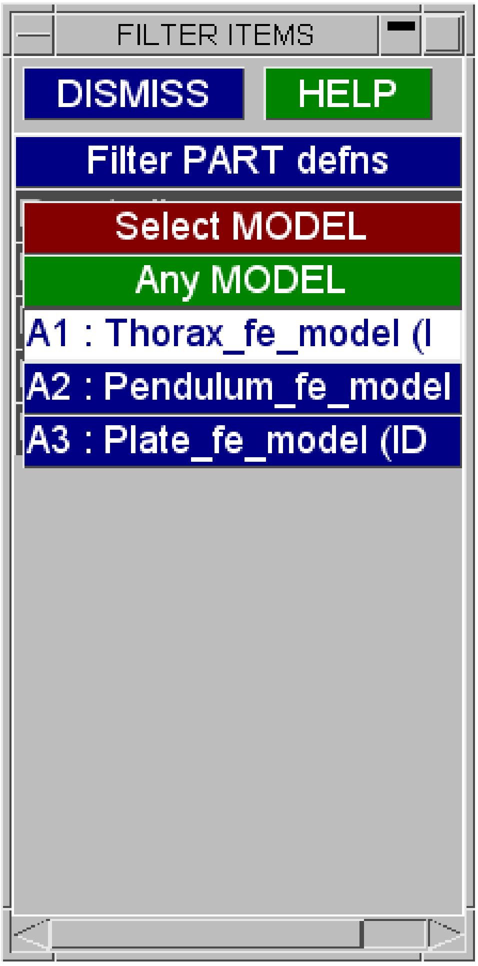
Using FILTER to limit what appears in the menu



Where the list of objects is short this method of selection presents no problems. But in some cases the list may be hundreds or even thousands of items long, and a method of cutting down what is displayed is required. This is provided by the **FILTER** button at the top of this box.

This allows you to control what is displayed in the selection menu by providing a series of tests against objects are compared before they are included. The tests vary by object type, those for PARTS are shown here. By default all tests are unset (**ANY**), but you can set any combination: multiple ones combine in effect.

Example of setting a FILTER

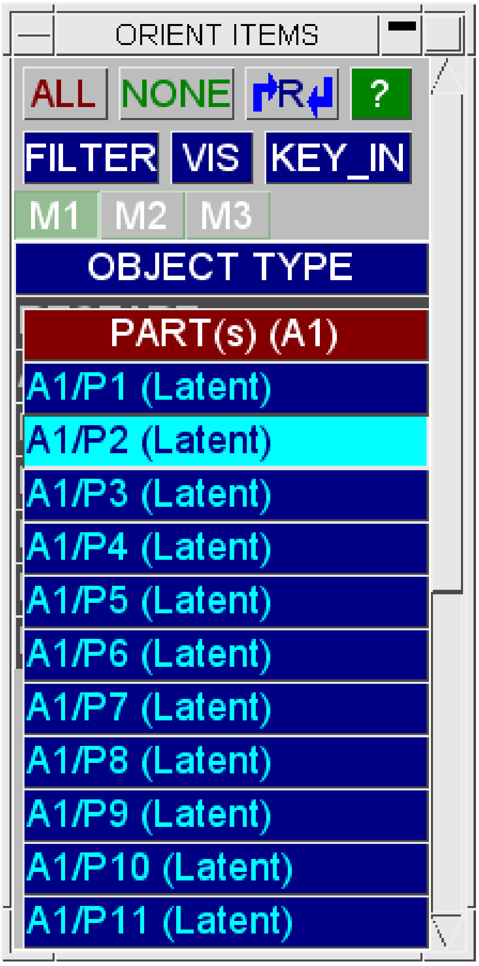


Here the **AIRBAG...** option for PARTS has been selected.

You are presented with all possible airbags in the model(s), and can choose one. The **ANY** default may be chosen, to revert to no filtering by this category.

An **<undefined>** category is sometimes included. This is because airbags may contain (say) PARTs referencing ELEMENTs that have not been defined yet will have a <null> element type entry.

The influence of selecting a FILTER option

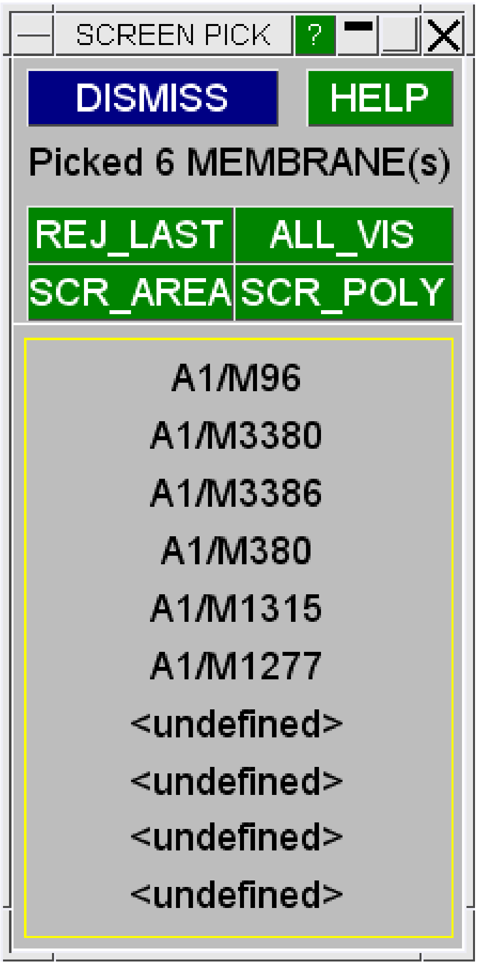


In the example shown here the user has selected **MEMBRANE** as the element filter. This causes the selection menu to be updated immediately to show only those PARTs which reference membrane elements.

Note that the **ALL** and **NONE** options ***will now only operate on the parts shown here.*** They will not affect the selection status of anything picked previously that does not now appear in the menu list.

Using VIS(ible) screen-picking to select items

FOLDER allows multiple menus to be active concurrently, each of which may require a picking operation (e.g. Modify Part, Delete Element, etc). For these menus as well as selecting items from a menu you may pick them from the screen using the ***left*** mouse button.When such a menu is invoked or bought to the front using the menu tabs, it automatically takes control of interpretation of screen-picking. The user can cause any capable menu to control screen picking by clicking the white cross in the top-left of the menu.



Picked 6 MEMBRANE(s)

A1/M96
A1/M3380
A1/M3386
A1/M380
A1/M1315
A1/M1277
<undefined>
<undefined>
<undefined>
<undefined>

Screen-picking is always "live" in the graphics window once you have selected an object category that is capable of being picked, it is not necessary to select **VIS** explicitly. Screen-picking of items can be accomplished in any of three ways:

"Scalar" picking of single items	Just click on the approximate centre of the item to select it.
"Rectangular Area" picking of a range of items	Click and drag out a rectangular area. Everything within the area is selected.
"Arbitrary polygon" picking of a range of items	Select **SCR_POLY**, then define an arbitrary polygon of up to 100 sides. Everything within the area is selected.

Screen-picked entries (by any method) go into the cursor list, of which the 10 most recent entries are shown in this box.

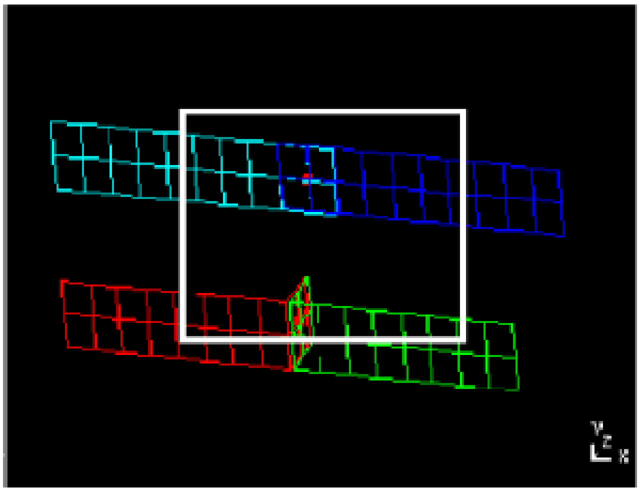
Note that:

- The current **FILTER** setting also applies to screen-picking: ***you will not be able to pick an item that has been filtered out.***
- Multiple (Area or Polygon) picking is only available in contexts where it makes sense. If, for example, you are picking a single node for an element you will not be permitted to drag out an area. The cursor symbol gives a prompt: a "cross" permits only scalar picks, a "hand" permits multiple picks.
- When 3D elements are picked by area or polygon the treatment of elements inside a mesh, which are not drawn because all their faces are "internal", depends on the **AREA_PICK** setting below.
- Screen-picked items can be rejected in a range of ways - see below

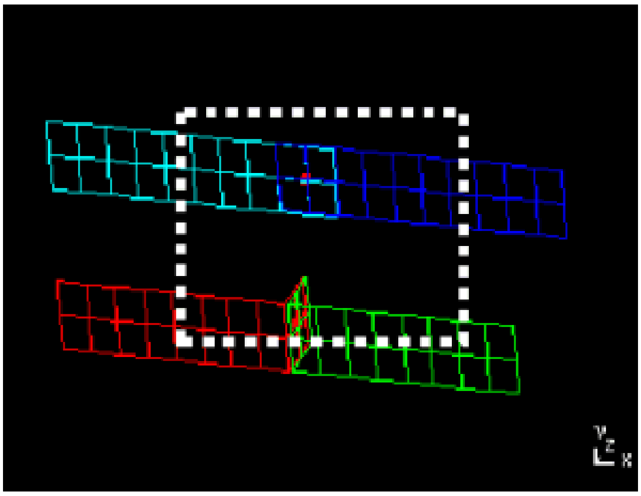
Rejecting items that have been screen-picked.

Picked items can be rejected (deselected) in exactly the same way that they were selected by using the middle and right mouse buttons:

Mouse Button	Function
🟩 □ □ LEFT	***Selects*** items: scalar, by rectangular area or by arbitrary polygon as described above. A thin, solid white line is used to define areas and polygons.
□ 🟥 □ MIDDLE	***Rejects*** the most recent selection: "last in, first out".
□ □ 🟥 RIGHT	***Rejects***: • What is explicitly selected (scalar pick) • All items in the area (multiple pick) A thick, broken white line is used to define areas and polygons.



Left Mouse button ***Selects***:
Solid borders for areas and polygons.

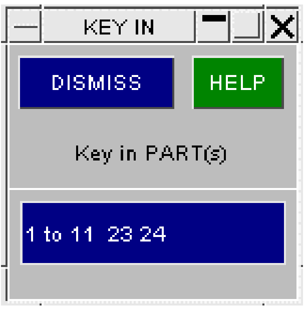


Right mouse button ***Rejects***:
Broken thick borders for areas and polygons.

AREA_PICK: What is "visible" when area or polygon picking

The test is simple: if it has been drawn, even if it is obscured by something else, it is "visible".

Using KEY_IN to type in selections



1 to 11 23 24

It is also possible to type in selection labels by invoking the **KEY_IN** box. Valid syntax is:

- Single labels: 1 101 27 93
- <start> to <end>: 1 to 21 99 : 1000

Or any combination of these. (Note that either "to" or ":" may be used to denote a range.)

"Key in" syntax when airbag and/or type codes must be defined for labels.

In the example above the airbag id and type code (Part) were both known, so simple numbers were adequate.

However in some situations multiple types may be possible (for example "element" permits "membrane, mass, ...") and the type code acronym must prefix the labels.

For example to select:	**Membrane 27 *and* Mass 1 to 20**	You must define	**M27 AM1:AM20**

It is also possible that selection across multiple airbags will be permissible.

For example to select:	**Airbag 1: Membrane 27 and** **Airbag 2: Mass 1 to 20**	You must define	**A1/M27 A2/AM1:A2/AM20**

How explicit menu selection, screen-picking and keying-in work together

These three methods of selection co-exist with cumulative effect: they are simply alternative ways of selecting objects for processing and are designed to be used together.

Selecting something by screen-picking or typing in its label will automatically depress the appropriate menu row, likewise deselecting the menu row of an item that has been screen-picked acts like rejecting a pick, and removes it from the cursor list. You can use any combination of methods in any order to select items. (Screen picking, or keying in the label of, an item that has already been selected manually from the object menu is legal, but has no effect.)

Selections are *not* cumulative across different item types

If, for example, you select the type PARTs and then swap to ELEMENTs, the PARTs will no longer be selected - only the selected elements will be remembered. If you wanted to select all elements from one PART, and then a subset of elements from a second PART, you could do it as follows:

- Select object type ELEMENT;
- Set filter option "by PART" and select the first part;
- Select "ALL" elements (implicitly only in that PART);
- Unset the filter and select the required further individual ELEMENTs explicitly.

The selection list will contain the results of both categories of selection.

Selections persist following most operations (except BLANK and DELETE)

When you have made your selections, and carried out the relevant operation, the selections remain in memory if this makes sense in that context. Thus you could carry out some other operation on the same list, add to or subtract from them prior to a further operation, and so on.

However exiting from that operation (for example leaving the **ORIENT** menu) will destroy any current selections. For this reason it may be better to iconise a window to get it temporarily out of the way, rather than to **DISMISS** it. The former will not affect its selection status, whereas the latter will destroy it!

Exceptions are:

BLANKING once operated on the items chosen are deselected.

DELETE they will no longer exist!

To delete all current selections and start again

Using the **RESTART** row at the top of the object menu has the effect of canceling all current selections, unsetting the current object category, and resetting the selection process to its initial state.

Exiting from the current operation menu also clears any current selections as described above.

6.1 AIRBAGS

6.1.1 Folding Airbags

The airbag folder is designed to produce folded meshes from ones that are initially flat. Additionally, some facilities are provided to deal with 3-D initial configurations

The airbag folder can also generate an airbag mesh from scratch for some pre-defined geometries. At present this is limited to a star folded or a circular folded airbag. In future releases this functionality will be further enhanced.

During folding the airbag can be checked for distorted elements and initial penetrations. Once folded the airbag it can be positioned.

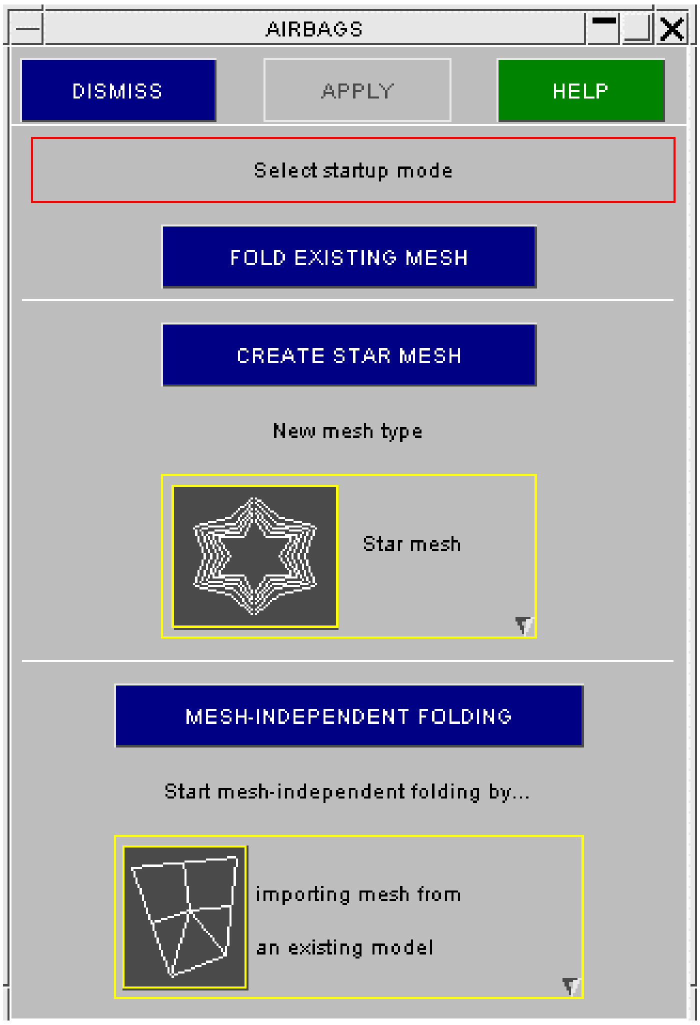
If you are starting from an existing mesh then each airbag must be a subset of only one model. Airbags usually consist of shell elements only and other element types should be avoided.

The airbag start up screen allows you to choose one of 3 possible modes.

1) Selecting **FOLD EXISTING MESH** will start the airbag folding process with an existing mesh.

2) **CREATE STAR MESH** can be used to create a new star or circular fold. To select whether to create a star fold or circular fold use the new mesh type popup box.

3) **MESH-INDEPENDENT FOLDING** allows you to create a circular airbag or import a mesh that is suitable for mesh independent folding.



Definitions: FOLD SETs, FOLDs and ORIENTs

This section defines some of the terms which are used in the airbag folder.

The use of the term "Airbag", has the potential to cause some confusion. The actual **AIRBAG** card in MADYMO consists of the surface of an airbag and the physical properties (gas thermodynamics) of the inflator. The tethers which might be included in a bag, for example, do not form part of the free surface of the airbag control volume, and thus they are not included in a MADYMO "airbag". The tethers, however, must be folded along with the remainder of the airbag, so they may need to be included in a geometrical definition.

Thus, to distinguish between the MADYMO **AIRBAG** and the airbag as described here, the term FOLD SET is used in FOLDER. In fact, a FOLD SET could potentially involve things which are completely unrelated to airbags: it is the umbrella definition containing everything required to define the geometrical extent of an airbag, and its associated folding operations:

- The fold set label (which must be unique within a model) and title;
- A list of elements and nodes (as sets) which comprise the bag;
- A list of folds;
- A local coordinate system.
- A list of orientations

A **FOLD** is a generalised term for the many fold types available; eg Rolling a bag up is described as a "FOLD", as is a "Tuck" or a "Scrunch". Each FOLD definition contains:

- The fold number and type (thin, thick, roll, tuck, ...)
- An optional coordinate system;
- Geometrical data (location, direction, angle, thickness, ...)
- Optional subsets of nodes and elements for special cases.

An **ORIENT** is a transformation which is applied to the folded airbag to position it in the model. The different types available are translation, rotation and scaling. Each ORIENT contains:

- The orient number and type (translate, rotate or scale)
- Geometrical data (location, distance, angle ...)
- Optional nodes for special cases.

A FOLD SET definition may contain any number of folds and orients, and a model may contain any number of FOLD SETS. Elements and nodes may be referenced in more than one FOLD SET, but this would not normally be sensible as the different fold operations might conflict: remember that a node can only have one current coordinate!

Creating and folding a new airbag from scratch

At present the following types of airbag mesh can be created:

A circular folded airbag. The airbag is compressed radially. To enable this the excess fabric forms folds.

A ‘star’ folded airbag. This is formed identically to the circular bag but an extra operation is performed. The airbag is pushed inwards at various points forming a star shape.

The star fold panel is shown in the figure to the right. This panel allows you to define the parameters which will be used to generate the mesh for the airbag. The parameters that can be changed are:

No. of points The number of points on the star fold.

No. of folds The number of out of plane folds which are done.

Element size The optimum size of elements which will be used when generating the airbag mesh.

Inflator rad The radius of the inflator at the centre of the airbag. This area will not be folded in any way. The inflator area on the bottom surface of the airbag will also be put into a different part. This allows the inflator part to be made rigid if necessary.

Unfolded rad The external radius of the airbag when unfolded flat.

External rad The maximum radius of each point on the star. i.e. the radius at the point tip.

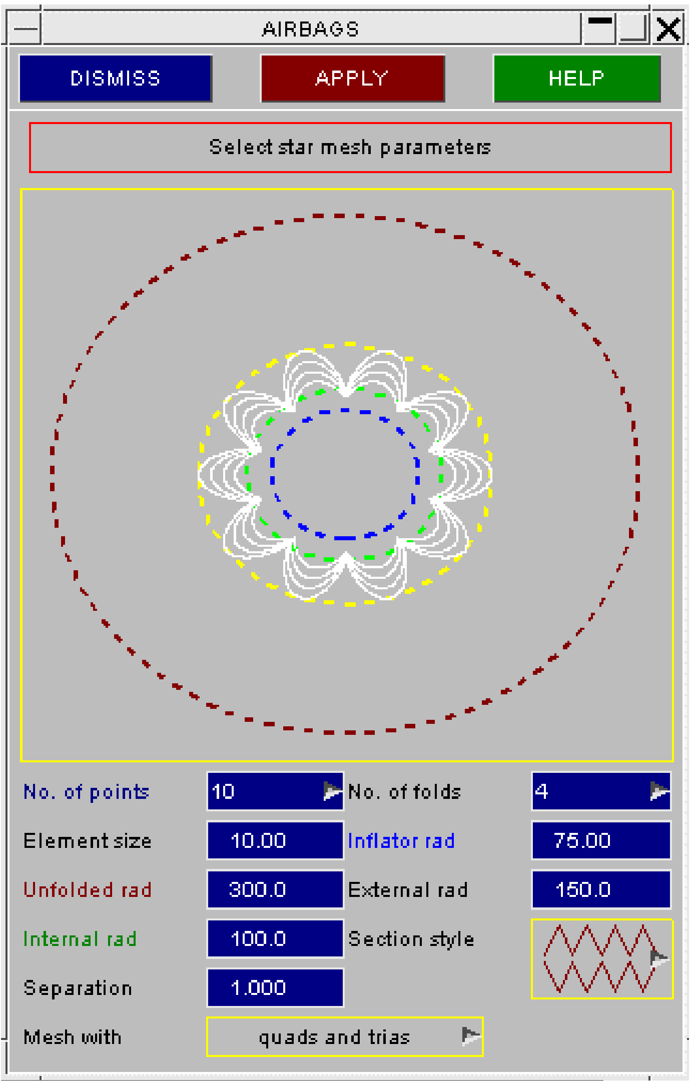
Internal rad The minimum radius of each point on the star.

Section style The cross section style of the folds used. The popup can be used to select two different styles.

Separation The separation between the upper and lower surfaces of the airbag when unfolded flat.

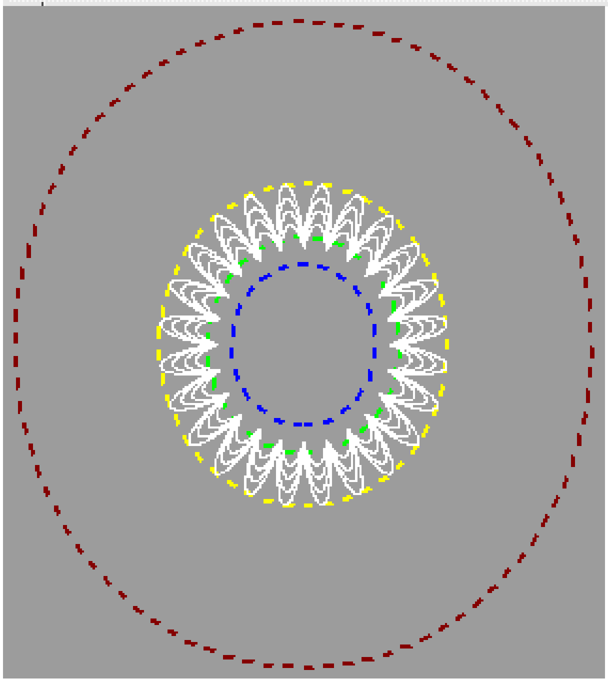
Mesh with The airbag can be meshed either with trias or with a mixture of (mainly) quads and trias. This popup can be used to select which you want

If you change any of the options the graphic also changes showing you the effect of the change. For example, the right-hand figure shows the effect of changing the number of points in the star fold to 24.

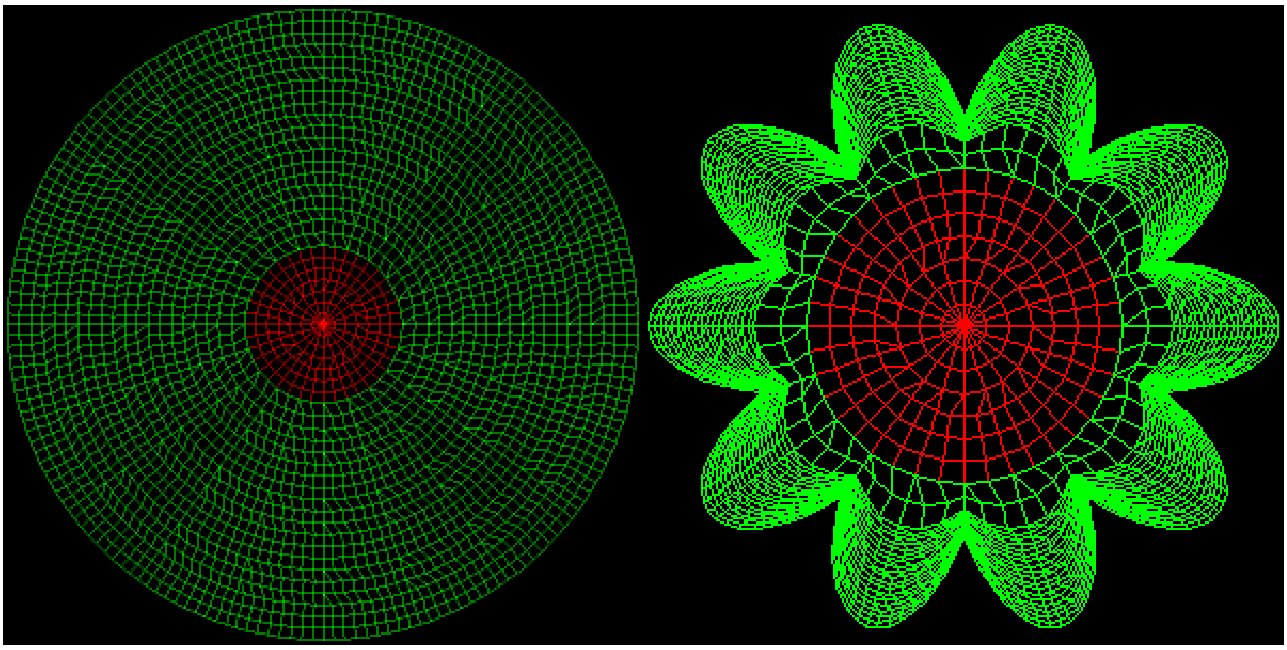


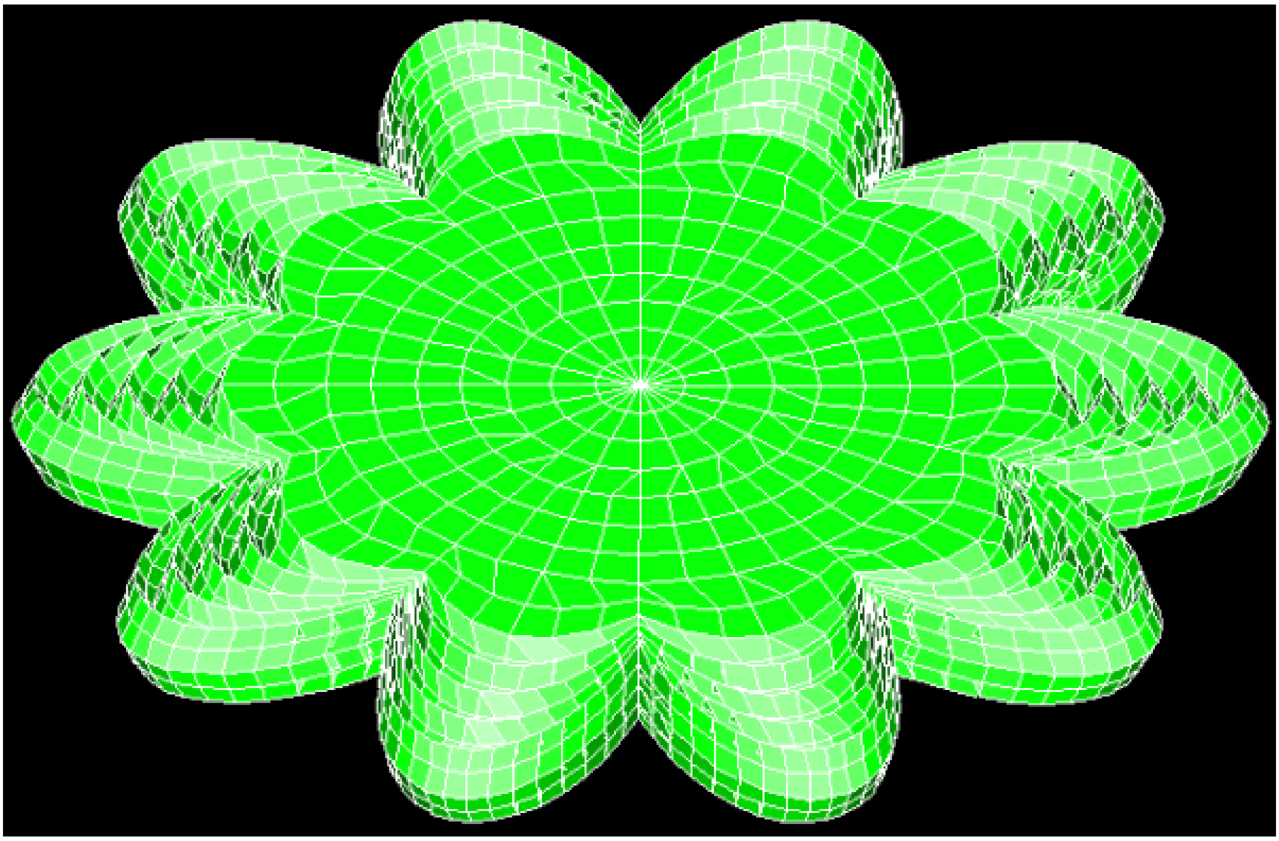
Select star mesh parameters

No. of points	10	No. of folds	4
Element size	10.00	Inflator rad	75.00
Unfolded rad	300.0	External rad	150.0
Internal rad	100.0	Section style	
Separation	1.000		
Mesh with	quads and trias		



The following figures show a starfold with 10 points before and after folding.

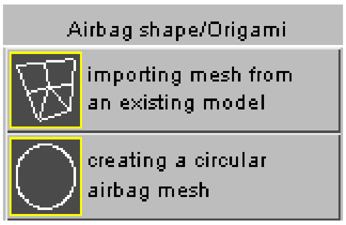




Once the star fold has been created you will be placed in the normal airbag folder. You can then position the bag, check for distorted elements etc.

Once the star fold has been meshed (created) you cannot change the number of points or other parameters. This is because the mesh is dependant on these parameters. If the airbag is not what you expected or required then the process needs to be repeated.

6.1.2 Mesh independent folding


Airbag shape/Origami

importing mesh from an existing model

creating a circular airbag mesh

Mesh independent folding allows you to create folds on the airbag at any position, regardless of the mesh on the airbag. It does this by remeshing the airbag after each fold to create a suitable mesh.
For this to work the airbag (or fold set) has to be set up in a specific way.

Currently there are 2 methods for doing this.
1) Create a flat circular bag from scratch.
2) Import a mesh

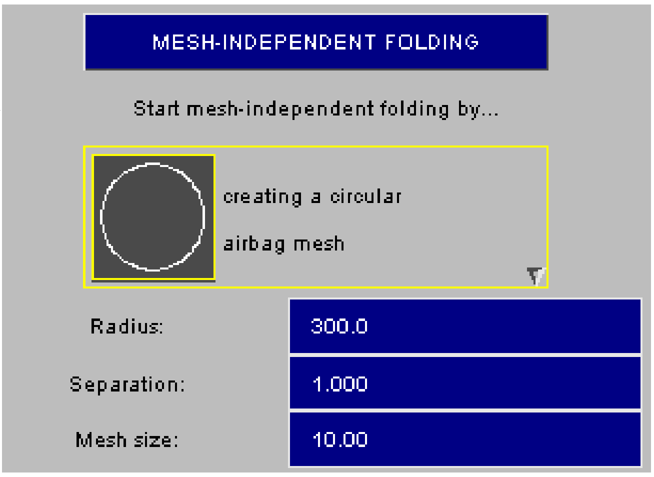
Alternatively, if an airbag has already been defined by one of these methods you can select the existing airbag.

Creating a circular airbag

This option is only available if you have not read an airbag into FOLDER.

If you have read a model then the option will be greyed out. To enable it **DELETE** the models or restart FOLDER.

1) From the airbag shape popup select the Circular option.
2) Give suitable values for:
a) the airbag radius.
b) the separation between the top and bottom fabric layers.
c) the element size for the initial mesh.
3) Press the **MESH-INDEPENDENT FOLDING** button.


MESH-INDEPENDENT FOLDING

Start mesh-independent folding by...

creating a circular airbag mesh

Radius: 300.0

Separation: 1.000

Mesh size: 10.00

The airbag will be created and you will be placed in the main folding screen. See section below for details of how to perform mesh-independent folding.

Importing mesh for mesh independent folding

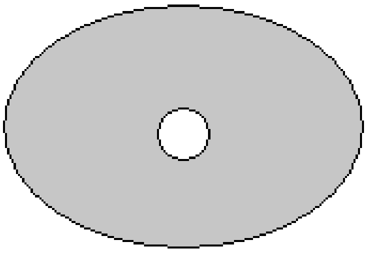
This option allows you to use a mesh that has previously been read into folder for mesh-independent folding.

1) Read an airbag file into FOLDER.
2) From the airbag shape popup select the Mesh option.
3) Press the MESH-INDEPENDENT FOLDING button.
4) Select the parts that make up the airbag.
5) Select fixed points on the airbag for remeshing.

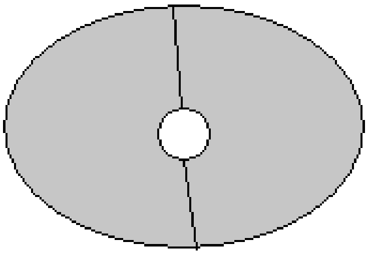
Selecting parts for mesh-independent folding

Folder needs to know which parts make up the airbag before mesh-independent folding can be done. There are limitations on parts that can be used:

1) Parts must be flat
2) Parts must not contain holes.
The algorithms that Folder uses when folding mesh-independent bags do not allow parts to have holes. If your airbag contains holes the parts need to be split.
For example

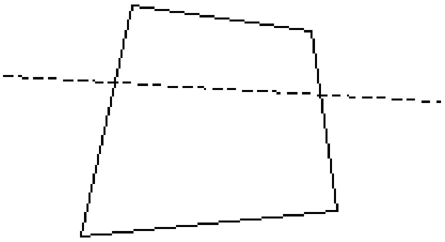


would become

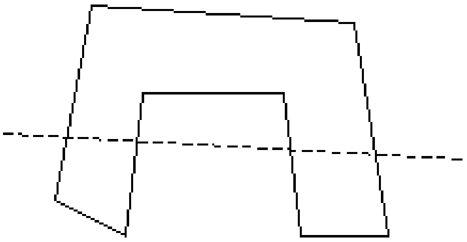


3) The top and bottom surfaces of the airbag must be different parts
4) If a fold will occur on a part, there must only a single fold line.

This part can be folded without problem.



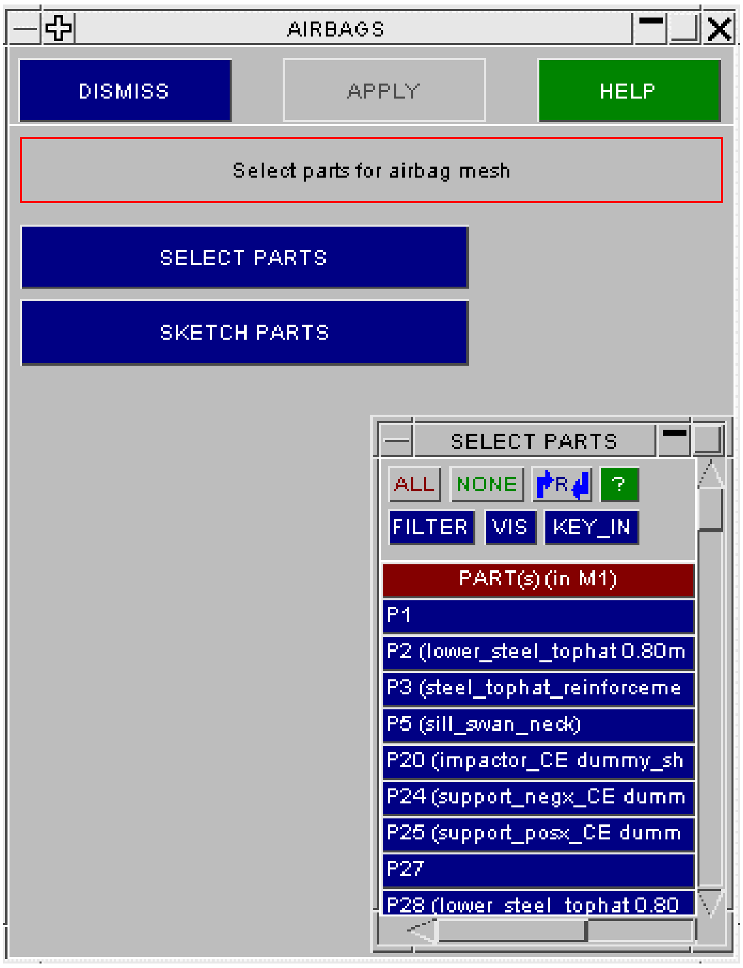
This part cannot be folded as the fold line cuts the polygon in two places.



Select the parts that make up the airbag and press **SELECT PARTS**.

You can sketch the parts you have selected by pressing **SKETCH PARTS**.
In this figure 4 parts are selected.

The following section shows some examples of meshes suitable for mesh-independent folding

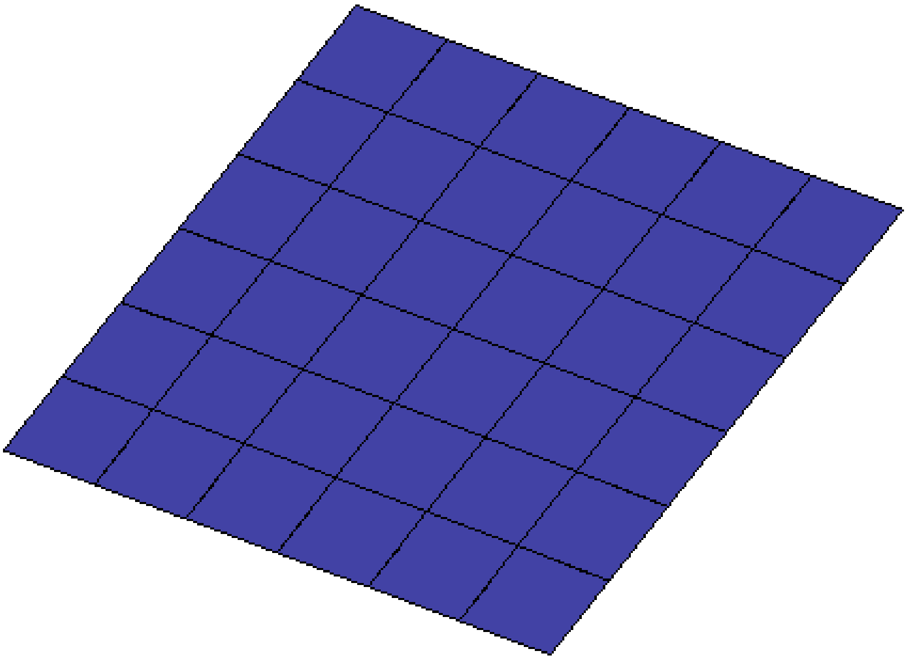


Select parts for airbag mesh

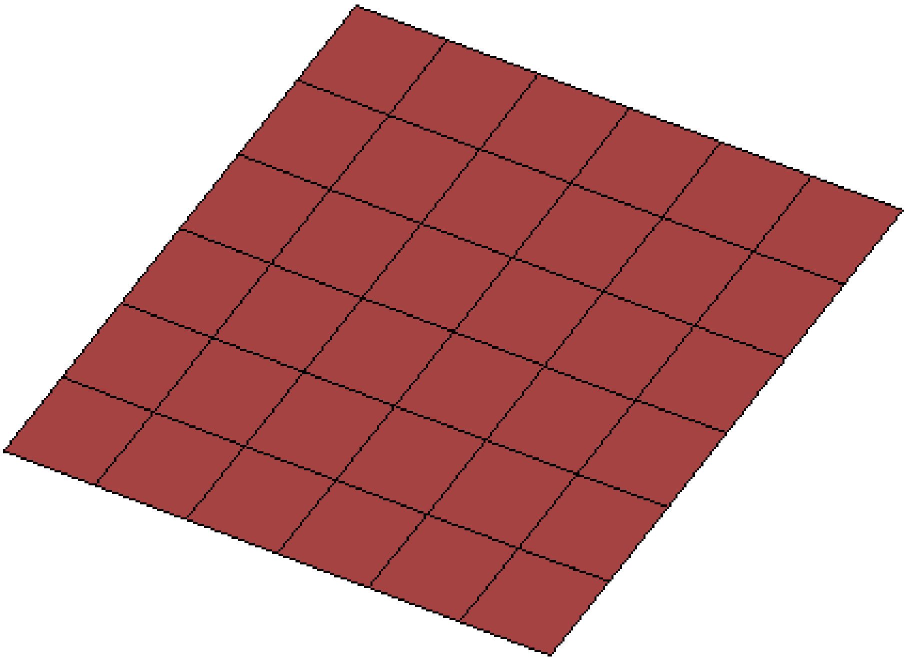
PART(s) (in M1)
P1
P2 (lower_steel_tophat 0.80m
P3 (steel_tophat_reinforceme
P5 (sill_swan_neck)
P20 (impactor_CE dummy_sh
P24 (support_negx_CE dumm
P25 (support_posx_CE dumm
P27
P28 (lower_steel_tophat 0.80

EXAMPLE 1

A square airbag is needed for mesh-independent folding.



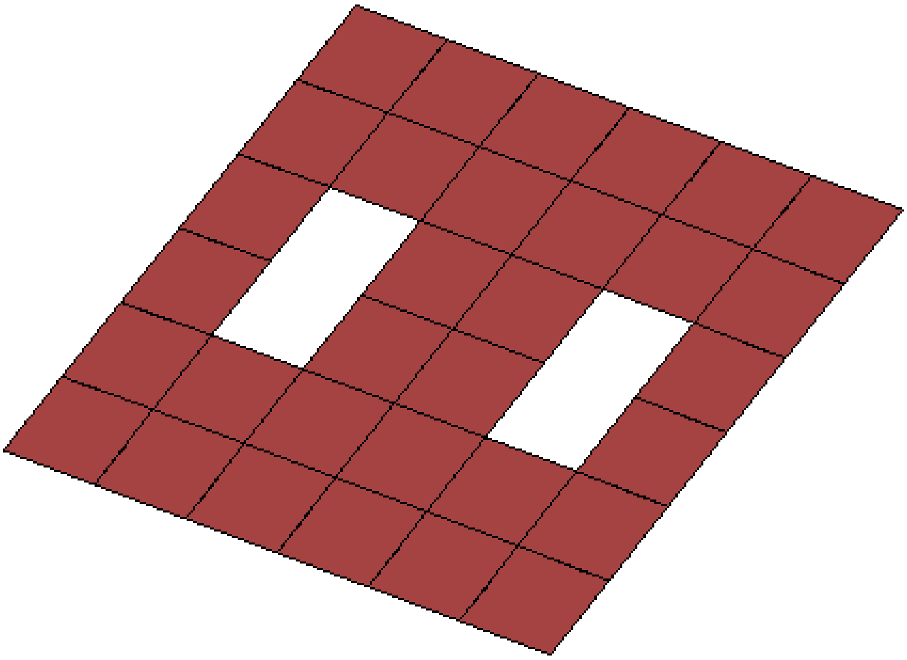
Top surface of airbag



Bottom surface of airbag

This airbag can be used for mesh-independent folding. The top and bottom surfaces of the airbag are different parts, both are flat, and neither have holes.

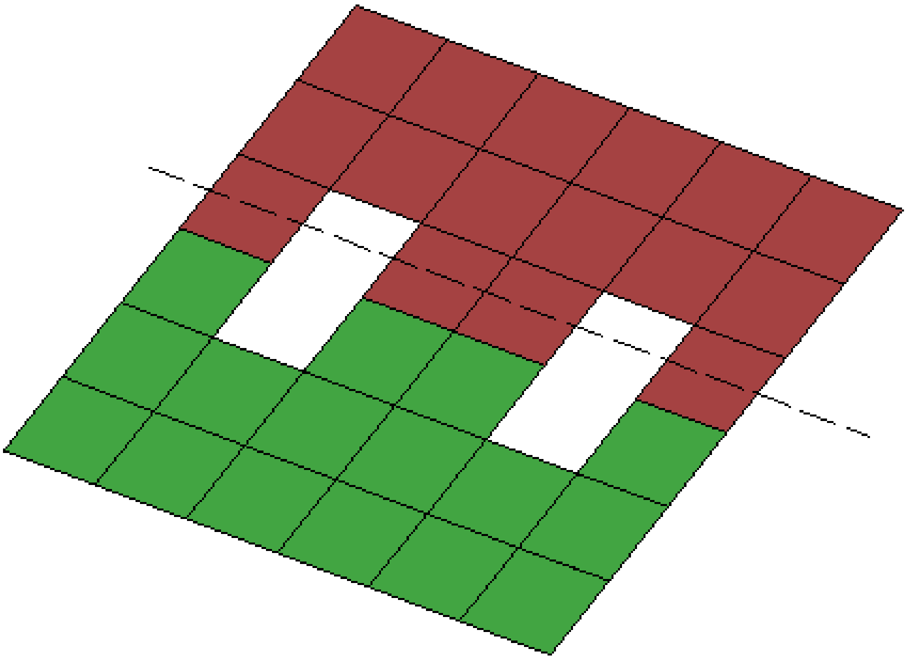
EXAMPLE 2



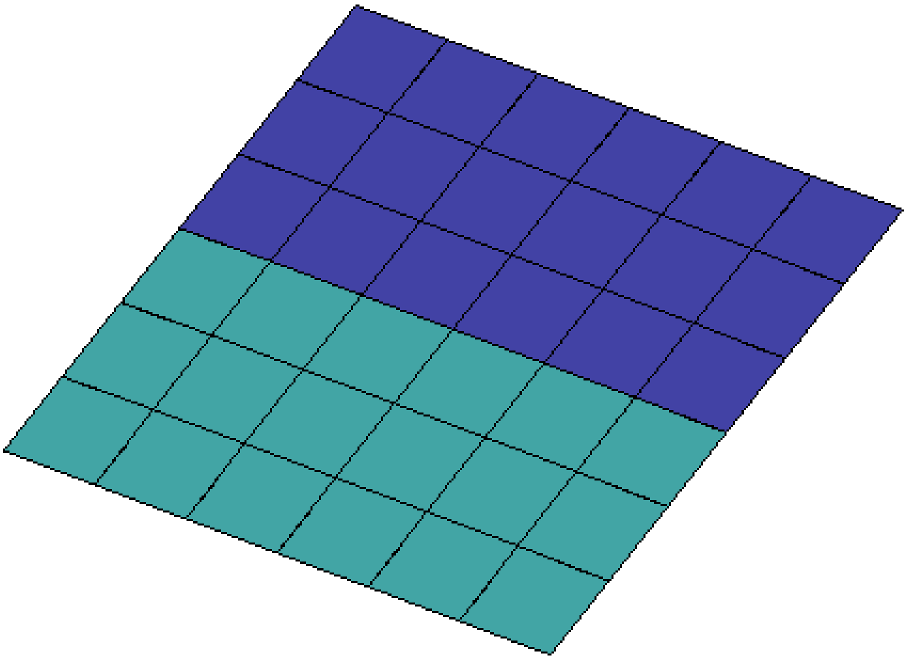
Bottom surface of airbag

This mesh cannot be used . The bottom surface of the airbag has holes in it.

To overcome this we can split the bottom surface into 2 parts. We also split the top surface to match



Bottom surface of airbag



Top surface of airbag

We have now eliminated the holes on the bottom surface so this airbag mesh can be used. Note that there would still be a problem if we were going to fold the airbag along the dashed line. In this case the fold line cuts the part in more than one place so will cause problems. If folds such as this are not going to be done the mesh is suitable.

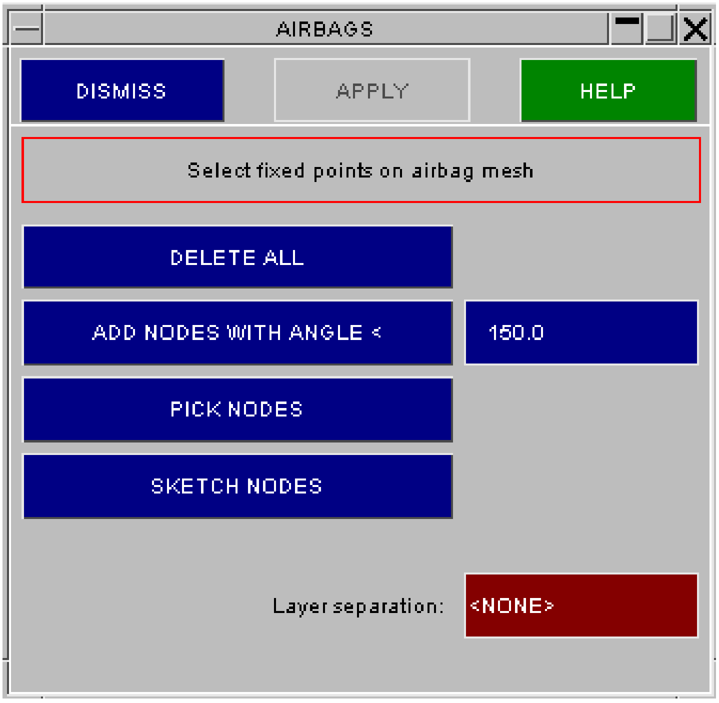
Selecting fixed points for mesh-independent folding

Once the parts have been selected, folder needs to know about the fixed points on the mesh.

The fixed points are required so that folder can remesh the parts in the airbag as a folding is done.

For example, to remesh the simple airbag shown in example 1 above folder would need to know that the corners of the square are ’fixed’ in space and so cannot be moved. All the other nodes on the boundary of the parts can be moved without changing the airbag shape.

The 4 corner nodes must be selected as fixed points. If no fixed points are selected folder does not know which nodes are essential and so cannot remesh the airbag as folding is done.



Select fixed points on airbag mesh

ADD NODES WITH ANGLE < 150.0

Layer separation: <NONE>

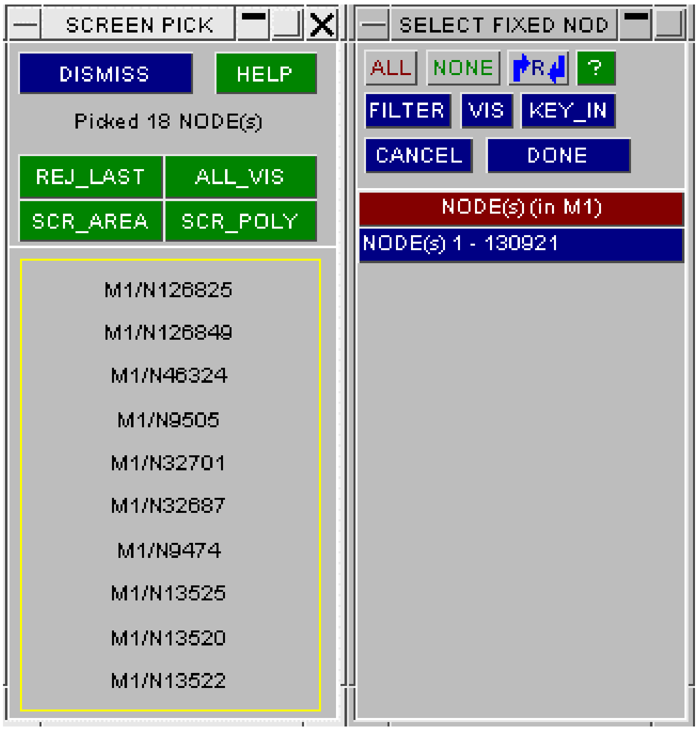
ADD NODES WITH ANGLE can be used to add nodes on the boundaries of parts which have an angle less than the specified value. For example the corner nodes on the square mesh in example 1 have edge angles of 90º so will be selected (< 135º). All the other boundary nodes have angles of 180º so will not be selected.

To enable folder to determine the different surfaces of the airbag you must enter the layer separation (the distance between the top and bottom surfaces of the fabric). In the screenshot above the value has not been entered yet so the **APPLY** button is not active.

Once all the fixed nodes that you require are selected, **APPLY** will create the fold set and take you to the main folding screen

PICK NODES can be used to manually pick nodes to become fixed nodes from the airbag.

When you have selected the nodes on the screen press **DONE** to add them to the fixed nodes

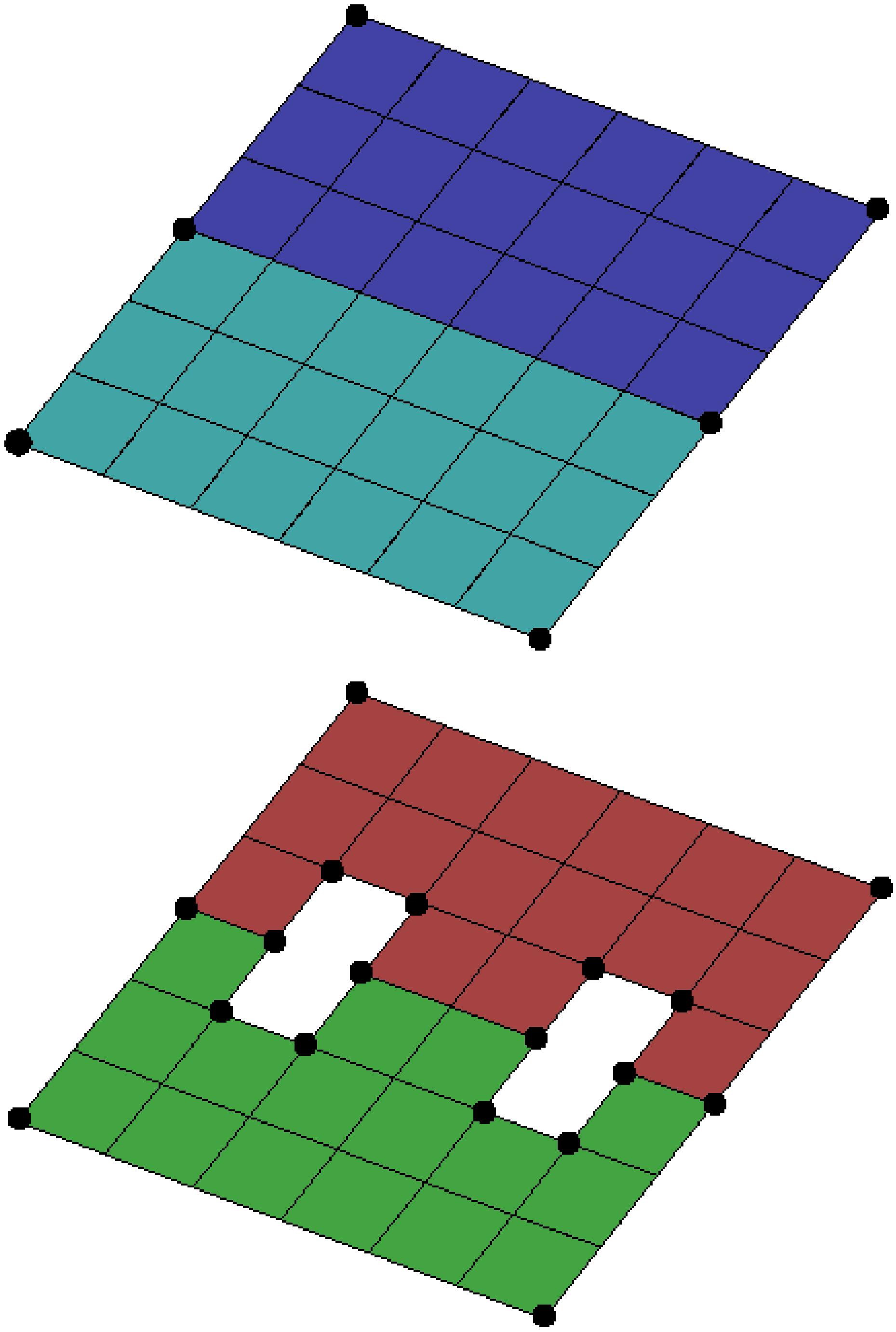


Picked 18 NODE(s)

M1/N126825
M1/N126849
M1/N46324
M1/N9505
M1/N32701
M1/N32687
M1/N9474
M1/N13525
M1/N13520
M1/N13522

NODE(s) (in M1)
NODE(s) 1 - 130921

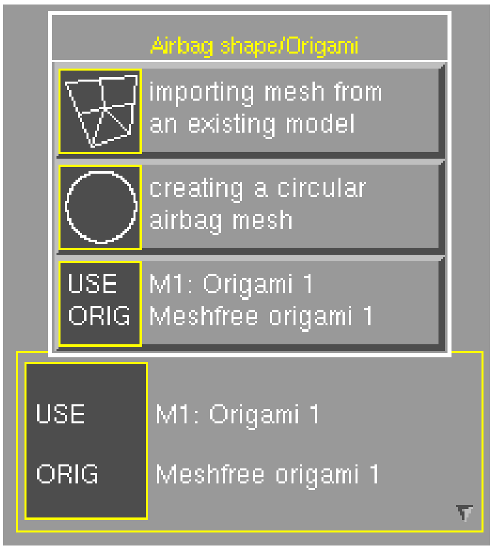
For another example, the mesh with holes in the bottom surface in example 2 earlier would need the following fixed nodes selecting (shown by the dots).



Selecting an existing mesh-independent fold set

If you have previously created a mesh-independent fold set you can return to the mesh-independent folder by selecting the fold set. In the screenshot on the right another option **USE ORIG** is available. For each mesh-independent fold set that exists an option will be shown.

A fold set will only be shown if **ALL** the folds in it are mesh-independent folds. If it is not shown it is because one or more folds have been done in the normal airbag folder. In this case to be able to return to the mesh-independent folder these folds would need to be deleted.



Performing mesh independent folding

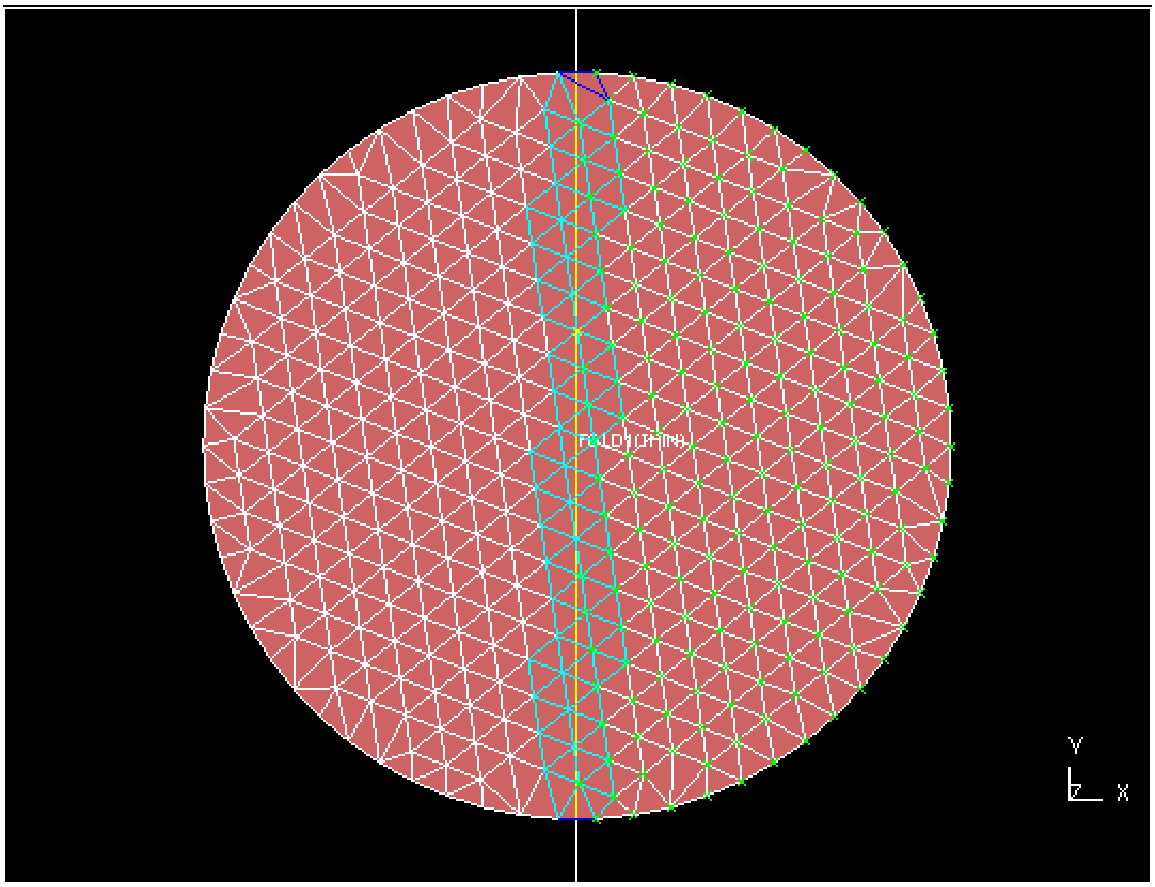
If the airbag has been created for mesh-independent folding or imported the **SPLIT MESH** and **REMESH** buttons will be available in the main folding window.
Mesh-independent folding is available for the following fold types:

- Thin folds
- Tuck folds
- Thick folds
- Spiral folds

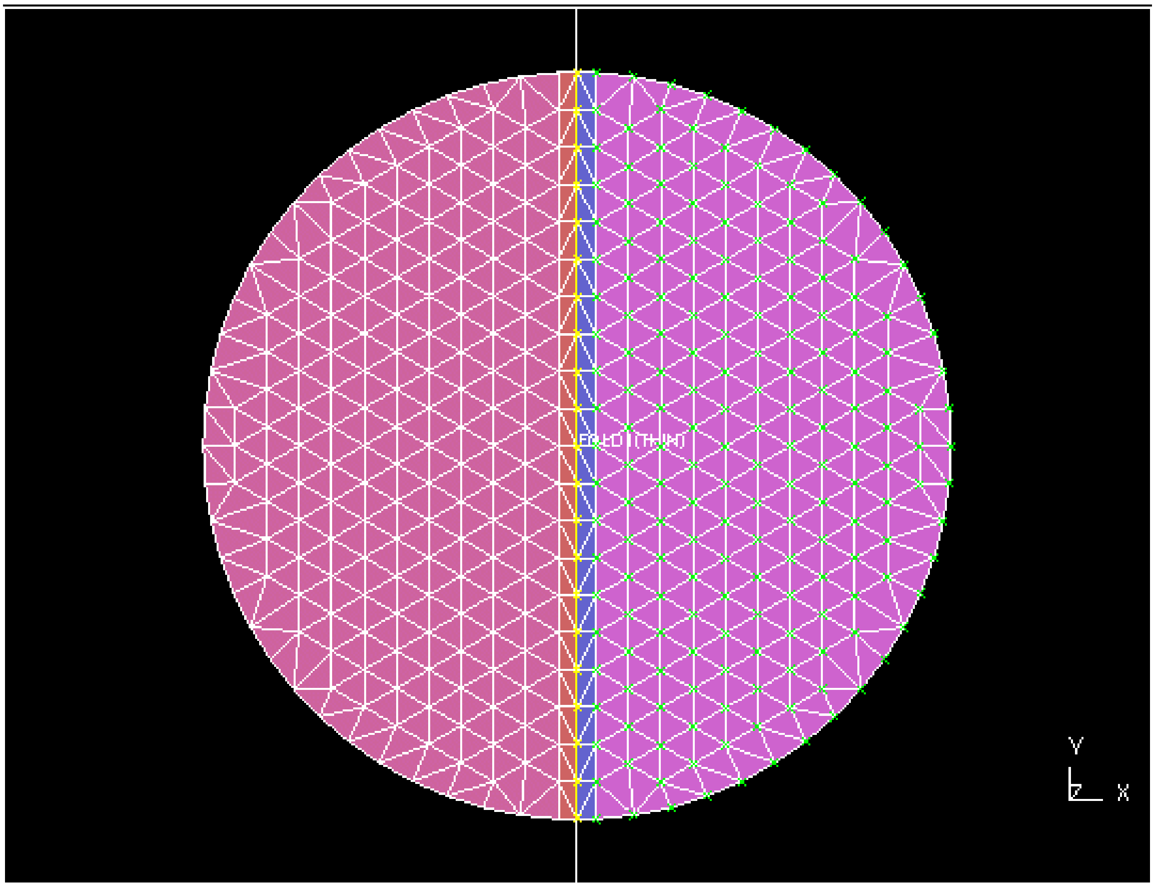
Other fold types are incompatible with mesh free folding and are not allowed (as the airbag is remeshed after each fold the fold definitions would change).

To perform a mesh-independent fold select the fold type, position angle etc as normal. In the example a thin fold will be performed.
Set the tramline size and element size to the required values in the options panel

Press **SPLIT MESH**.

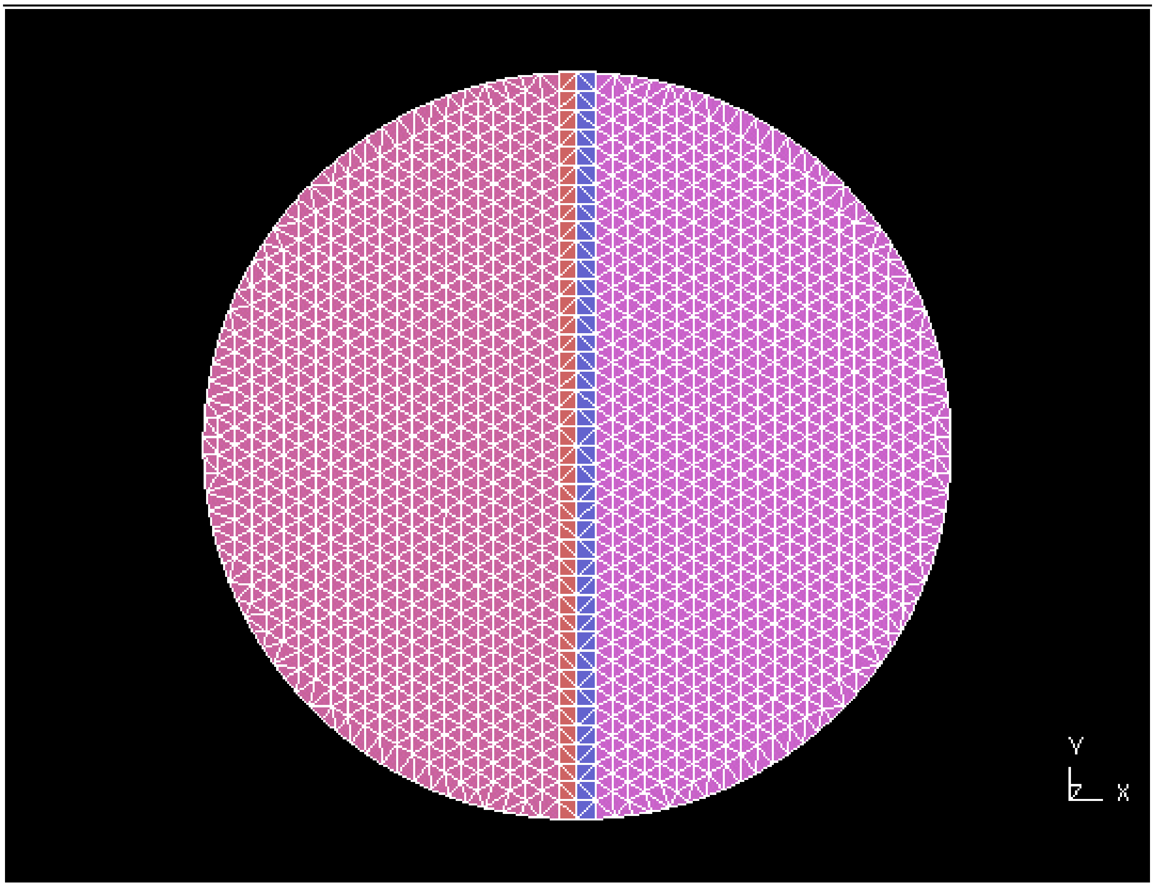


The mesh is split and remeshed. The example on the right shows the result of a thin fold.
The top and bottom surfaces of the airbag are split into new parts as required (as shown by the different colours) and then remeshed. Fixed points are automatically added to the airbag as required.
To undo a split **DELETE** the fold. The parts will be recombined and remeshed (as long as there are fixed points to enable folder to remesh)



At any time the element size in the options size can be changed and the airbag remeshed using the **REMESH** button. For example the airbag above has a tramline size of 5mm and an element size of 10mm. Changing the element size to 5mm and remeshing gives the mesh on the right.

Note that as the thin fold was made with a tramline size of 5mm, the airbag should not be meshed with elements smaller than 5mm as this could lead to more than one element across the tramline parts. This will cause problems with the thin fold.



6.1.3 Folding an existing mesh

The following sections deal with folding an existing mesh. There are several parts to this so it has been split up into several sections.

- Mesh orientation, airbag reference geometry and main orient command (this section).
- Airbag folding summary.
- Creating a fold set definition.
- Creating a local coordinate system.
- Plotting modes.
- Using the main folding panel.
- Creating a new fold.
- Fold types.
- Subset folding.
- Options available in the airbag folder.
- Positioning the fold set.
- Saving/reading fold set and fold definitions.
- Tips and notes for successful folding.
- Folding example.

Suitable initial orientation of the mesh

The ideal way to fold an airbag is to define the unfolded airbag in the X-Y plane, fold it, and then orient it in space with respect to the vehicle space. If it is not defined topologically to be in the X-Y plane it would be sensible for the user to define a local co-ordinate system such that the local system is planar with the airbag (see Section 6.1.6). When folding then takes place it will visually appear to be in the global X-Y plane. On exiting the airbag folder the bag will return to the global space.

However, it is strongly recommended that folding should start with the initial geometry in the global X-Y plane, as this will reduce the chances of confusion about where the geometry actually is, and make life simpler!

How the COORDINATE_REF.CARTESIAN interacts with folding

The COORDINATE_REF.CARTESIAN definition is also crucial to folding, as it is used as the basis for all folding operations. If no such definition exists when folding starts, then FOLDER will automatically copy the nodal coordinates *in their current configuration* into the reference geometry. (Any existing reference geometry for a node will not be over-written.)

This is not a wholly satisfactory solution, as an initial reference geometry which gives a satisfactory element shape for stress calculation during analysis may not prove an ideal starting point for folding operations: typically where a 3D bag needs to be split into several 2D panels for folding, and then reassembled. In this situation it may be necessary to save the "true" reference geometry (for analysis) in a separate file, delete it from the input deck used for folding in FOLDER so that a more satisfactory geometry can be used for folding each panel, then re-introduce it prior to analysis.

This is not a wholly satisfactory state of affairs, and the geometrical basis for folding may in future be changed to be independent of the reference geometry.

Interaction between the **ORIENT** command and folding

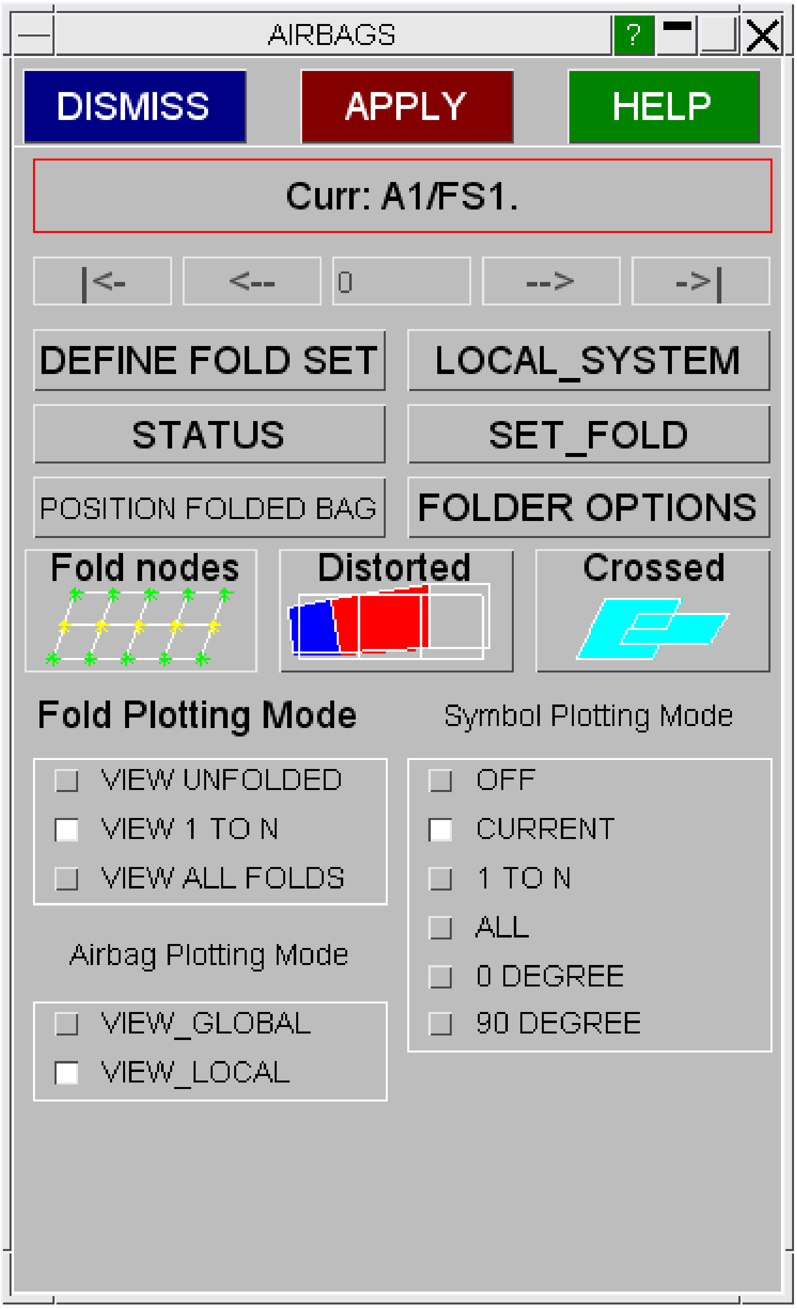
Both **ORIENT** and folding act to change the current coordinates of nodes, and the order in which they are applied is important since the most recently used will "win" in determining the final position of nodes. This is important since folding is always based on the *reference* geometry (which is unaffected by orientation commands), whereas **ORIENT** always operates on the *current* (ie as-folded) geometry. If you use **ORIENT** to position an airbag after folding and then return to the airbag folder at a later date to refold the airbag any orientations will be lost. To prevent this problem the airbag folder has built in orientation functions. These orientations are saved just like folds and so if a bag is refolded it can be repositioned using these stored orientations.

It is strongly recommended that you use the orientation functions build into the folder rather than the general orient functions of FOLDER so that any orientations you create are saved and can be modified or replayed in the future.

6.1.4 Airbag Folding Summary

The following process should be followed when folding an existing airbag mesh:

- Read in a model containing airbag geometry (and possibly Fold Set definitions), and enter the FOLDER airbag module by using the **AIRBAGS** buttons.
- Define a FOLD SET or select an existing one using **DEFINE_FOLD SET**.
- Set the local coordinate system if your airbag is not in the global xy plane using **LOCAL_SYSTEM**
- Set the plotting modes that you require using the Fold Plotting Mode, Airbag Plotting Mode and Symbol Plotting Mode radio buttons.
- Set any options for the airbag folder using **FOLDER OPTIONS**
- Define or modify folds using **SET_FOLD** using subset folding, sets and layers as appropriate.
- If required position the folded bag using **POSITION FOLDED BAG**
- Exit airbag folder by pressing **APPLY**. Note that other methods of exiting from this model will lose current fold definitions.
- Save the model to disk.



Curr: A1/FS1.

Fold Plotting Mode

- □ VIEW UNFOLDED
- □ VIEW 1 TO N
- □ VIEW ALL FOLDS

Airbag Plotting Mode

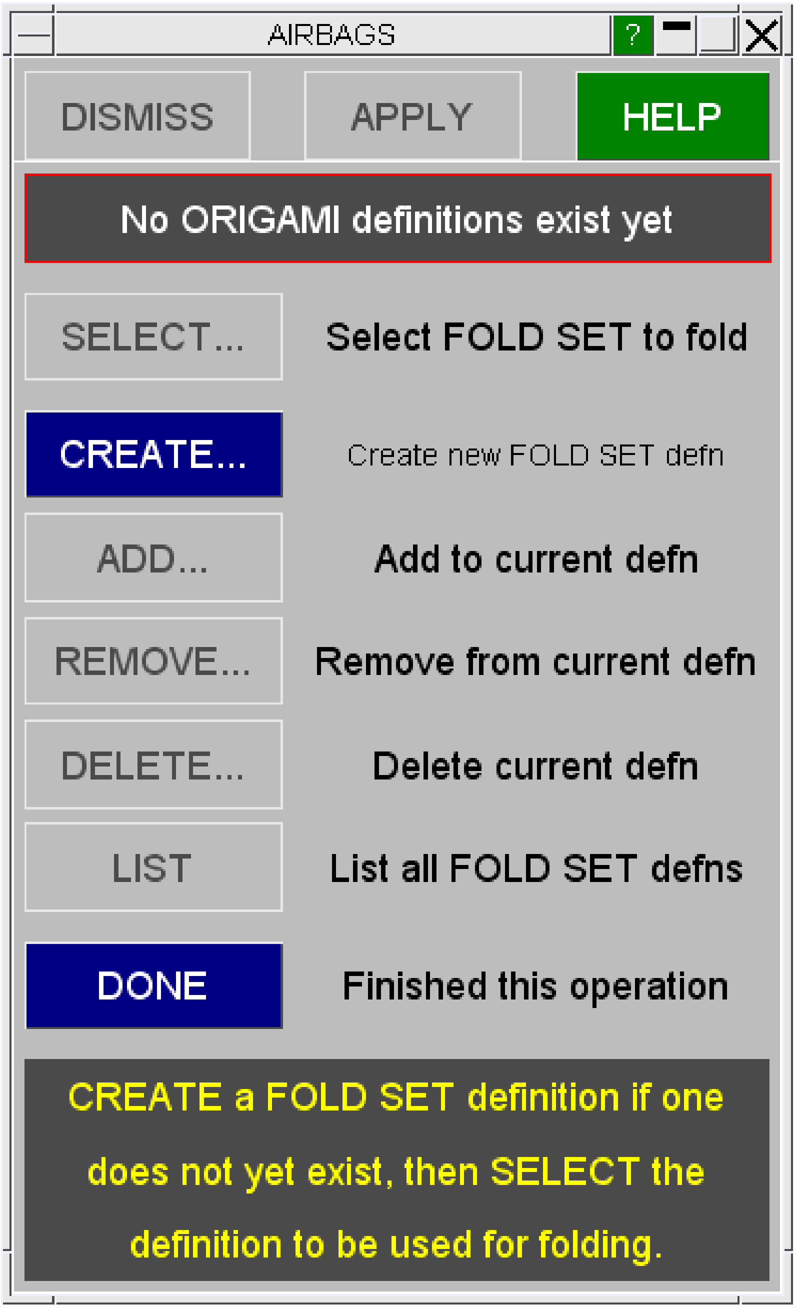
- □ VIEW_GLOBAL
- □ VIEW_LOCAL

Symbol Plotting Mode

- □ OFF
- □ CURRENT
- □ 1 TO N
- □ ALL
- □ 0 DEGREE
- □ 90 DEGREE

6.1.5 Define Fold Set: Selecting or creating a FOLD SET Definition

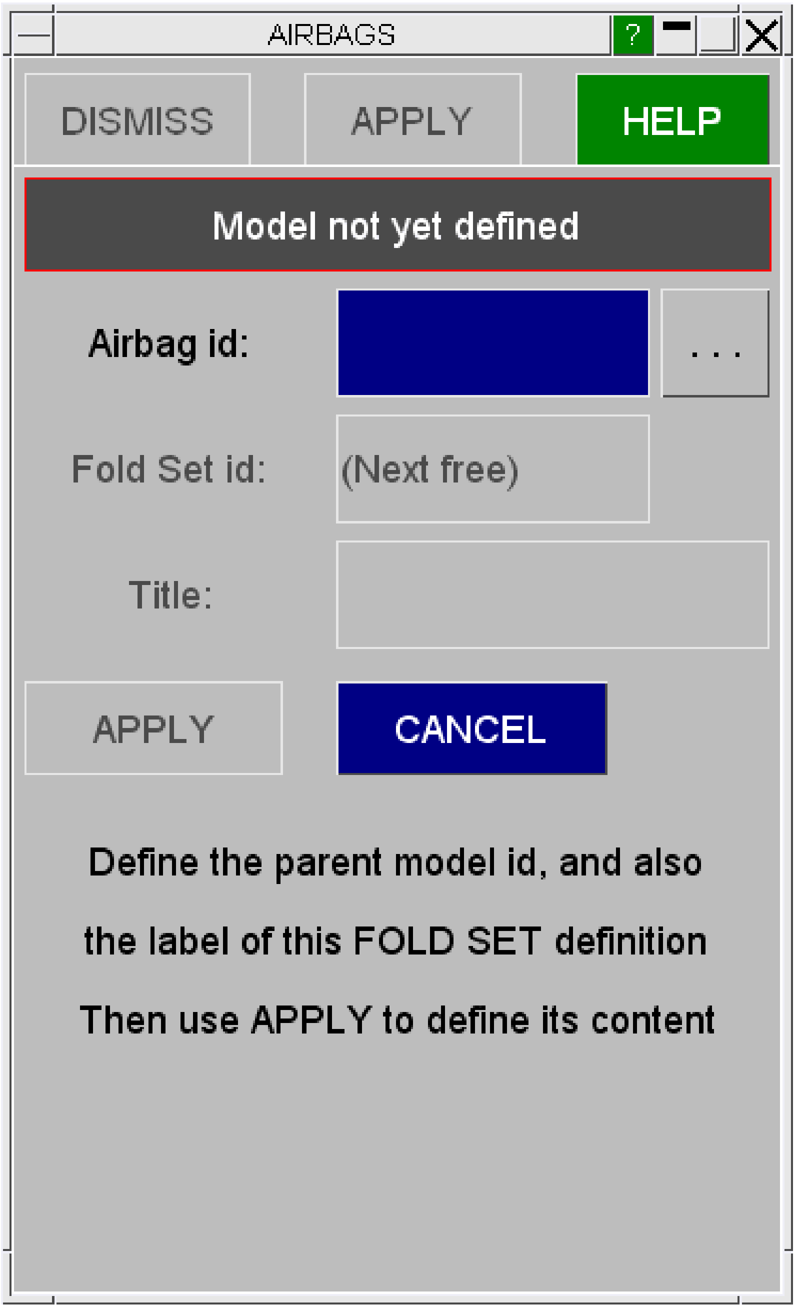
Before you can fold anything you must have a current FOLD SET definition. **DEFINE_FOLD SET** in the main folding screen above gives the Fold Set definition menu (above left). In this example there are no existing definitions, so it is necessary to **CREATE...** one:.



No ORIGAMI definitions exist yet

CREATE a FOLD SET definition if one does not yet exist, then SELECT the definition to be used for folding.

A **FOLD SET** definition can only exist in a single model, so the first phase of creation is to select a model, and then to define the Fold Set label and title. Any number of Fold Sets may exist within a model, but they must have unique labels.



Define the parent model id, and also

the label of this FOLD SET definition

Then use APPLY to define its content

Once the basic data has been defined you are presented with the standard selection menu which will allow you to define the SETs and/or PARTs and/or ELEMENTs which constitute this Fold Set definition. These define the nodes and elements which are to be folded.

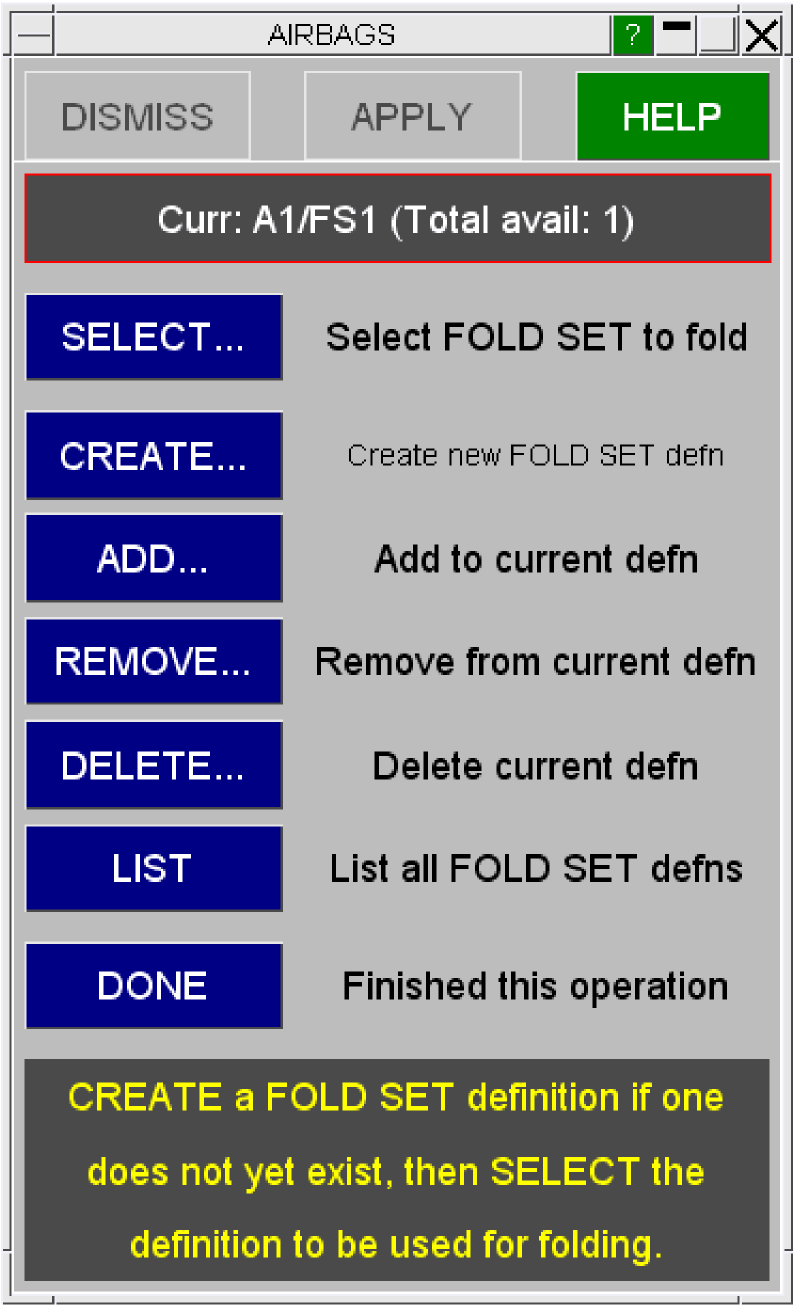
Finally the "COORDINATE_REF.CARTESIAN", which is used as the starting point for folding, is set up automatically by FOLDER. If this does not exist for any nodes to be folded, then it is created at this stage by copying the *current* geometry of those nodes.

The definition is now complete, and the Fold Set definition panel will now be fully populated as shown in the adjacent figure.

You can now **SELECT...** which definition you want to fold.

The other operations here, **ADD..**, **REMOVE..**, and so on are self-explanatory. Fold Set definitions can be edited at will by re-visiting this panel and manipulating them as required.

Use **DONE** to return to the main folding menu in order to proceed with folding.



CREATE a FOLD SET definition if one does not yet exist, then SELECT the definition to be used for folding.

The Fold Set definition is now a permanent part of your model, and will be written out as a separate "fold" file so that it can be re-read in future FOLDER runs. (Note that `*FOLD SET` is not a standard MADYMO tag, and it is placed in a separate file so that it will be ignored by the MADYMO analysis code.)

It is possible to edit the `*FOLD SET` data in a file by hand - Appendix II describes the format of this data - but it is ***strongly*** recommended that you do not attempt this as the data stored is quite complex: if you want to edit Fold Sets read them back into FOLDER and do the work there.

Also you should be very careful not separate `*FOLD SET` definitions from their "parent" input files, because they contain references to coordinate systems, sets, elements and nodes that exist uniquely within those files. If you want to keep standard airbag files "on the shelf" make sure that they are complete with geometry and folding data kept together: FOLDER will merge airbags and structural models for you.

6.1.6 LOCAL_SYSTEM: Defining Airbag Local Axes

In general it is easiest to fold a bag if it is oriented initially in the global X-Y plane. However, if it is already in a vehicle this is unlikely to be the case. The user can therefore move the bag to a more convenient folding position.

This is done by pressing **LOCAL_SYSTEM** which will invoke the menu shown on the right. The user should then define the local X-Y plane (referred to as the fold set local system) by selecting three nodes:

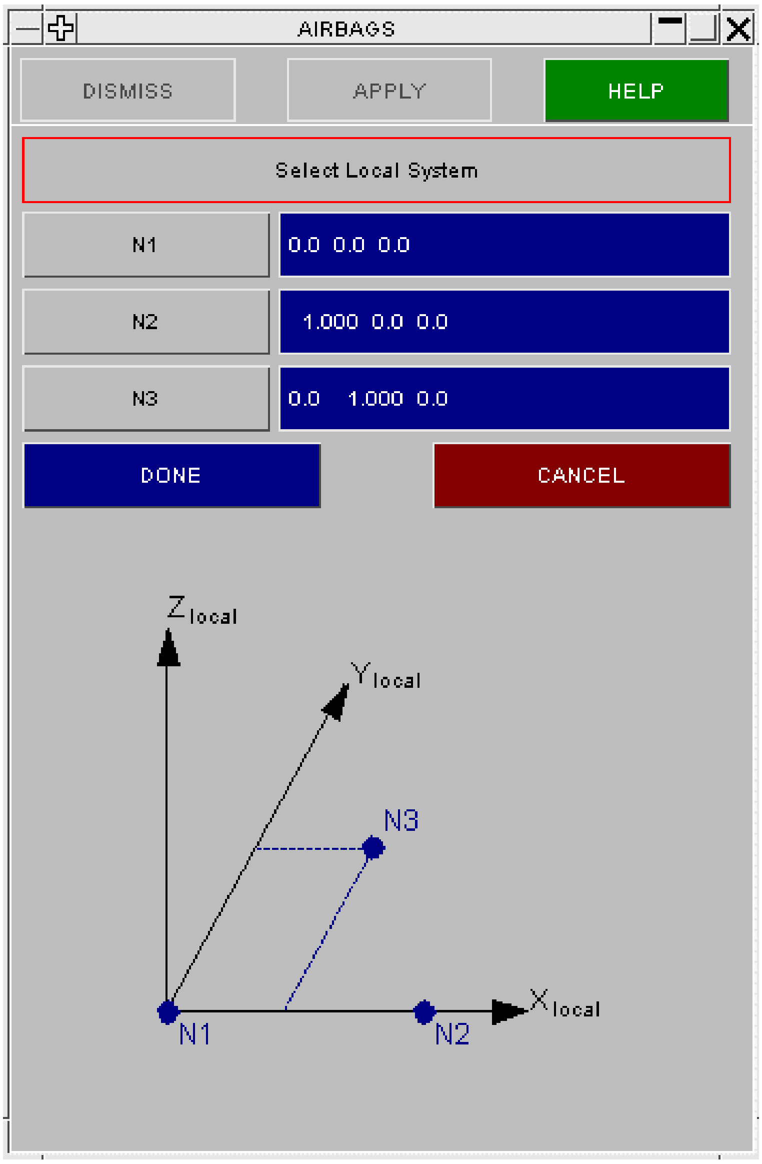
N1 defines the local axis origin;

N2 defines the local x-axis;

N3 defines another point in the X-Y plane.

Alternatively you can type in the local axis vectors, which FOLDER will normalise for you.

If this option is invoked when the current fold number is non-zero (see Section 6.1.8) the user can define a local axis system that affects the current fold only (referred to as the fold local system). Otherwise it applies to the Fold Set definition as a whole.



N1 0.0 0.0 0.0

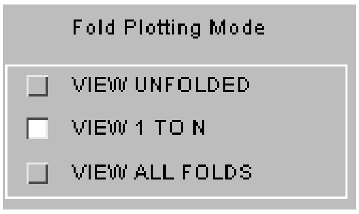
N2 1.000 0.0 0.0

N3 0.0 1.000 0.0

6.1.7 Plotting Modes

You can exercise control over how the Fold Set definition is drawn and annotated in a variety of ways. The following buttons are on the main folding window.

Fold Plotting Mode

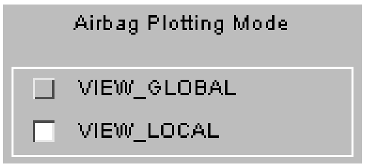


VIEW UNFOLDED displays FOLD SET without applying the folds to the displayed geometry;

VIEW 1 TO N displays the FOLD SET folded up to the current fold (see Section 6.1.9) excluding any other folds;

VIEW ALL FOLDS displays all folds defined on the current FOLD SET. This is not affected by the current fold number.

Airbag Plotting Mode (The coordinate system used for airbag display)

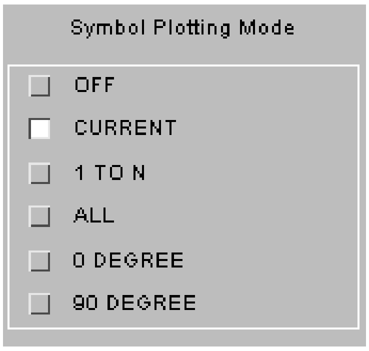


VIEW_GLOBAL Displays the airbag in the global cartesian system;

VIEW_LOCAL Displays it in its local system (if defined).

Symbol Plotting Mode (Plotting of fold line symbols)

Note that where folds slice through elements the actual fold line (ie along element edges) is shown as well as the defined fold line (ie across elements). The fold line symbol can be:



OFF No fold symbols are displayed;

CURRENT Only the current fold is displayed;

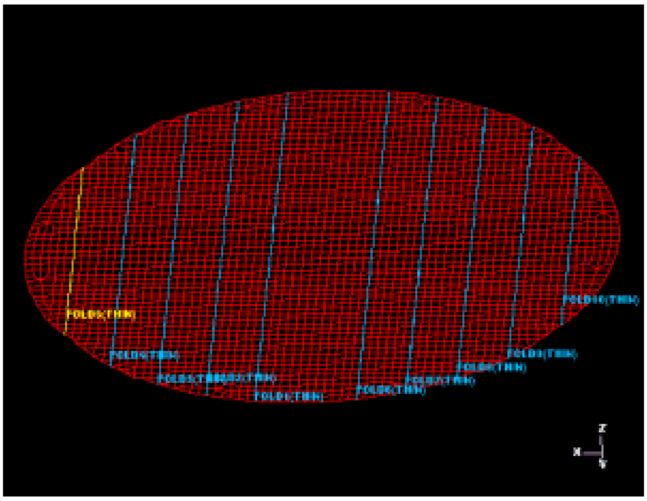
1 TO N Displays all folds up to the current fold;

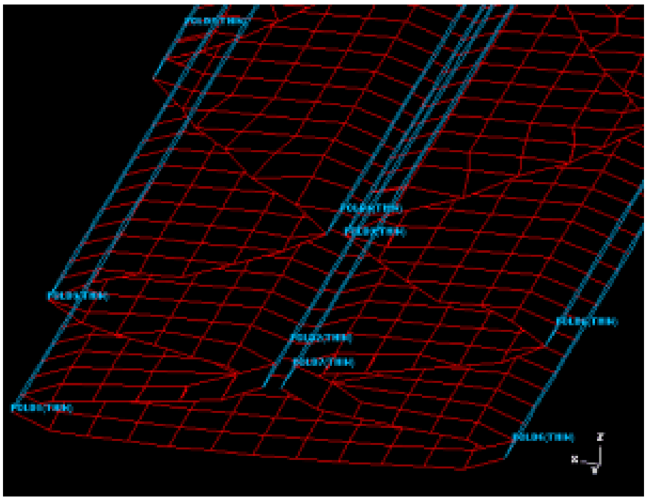
ALL Displays all folds;

0 DEGREE Displays all folds perpendicular to the (local) X-axis;

90 DEGREE Displays all folds parallel to the local X-axis.

The following two examples show typical "unfolded" and "folded" displays of the same airbag, with fold line symbols superimposed in both cases.



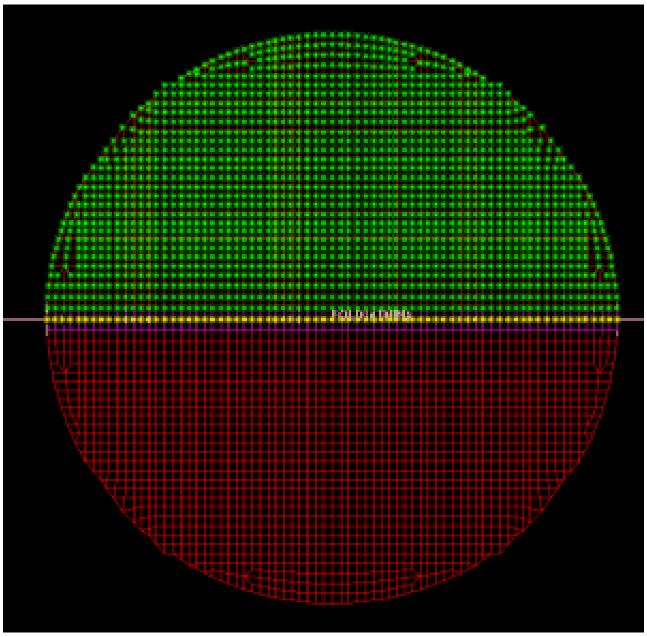


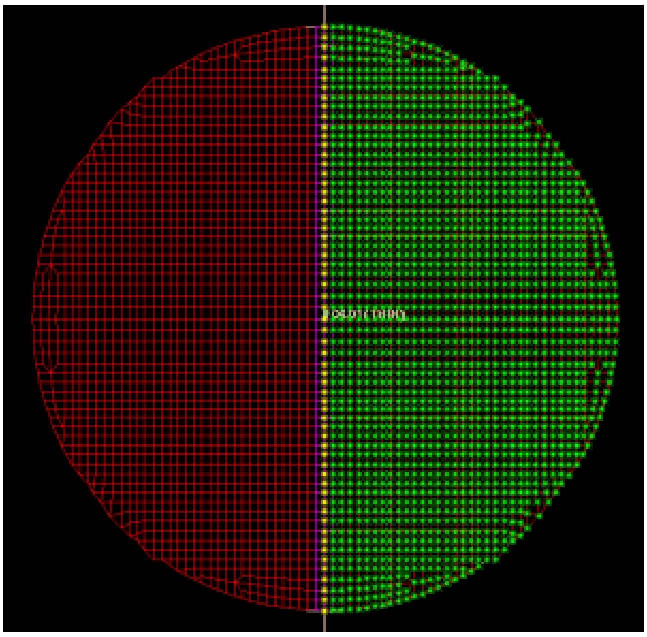
Unfolded mesh drawn in the global system showing all fold lines superimposed

Folded mesh (all folds) showing fold lines superimposed.

Fold Node plotting (Visualisation of fold nodes)

By default when you make a new fold the nodes which will be moved in the fold are highlighted. This helps to show if you have the correct nodes selected for the fold. For example the next 2 figures show which nodes will be folded in a 0º or 90º fold.

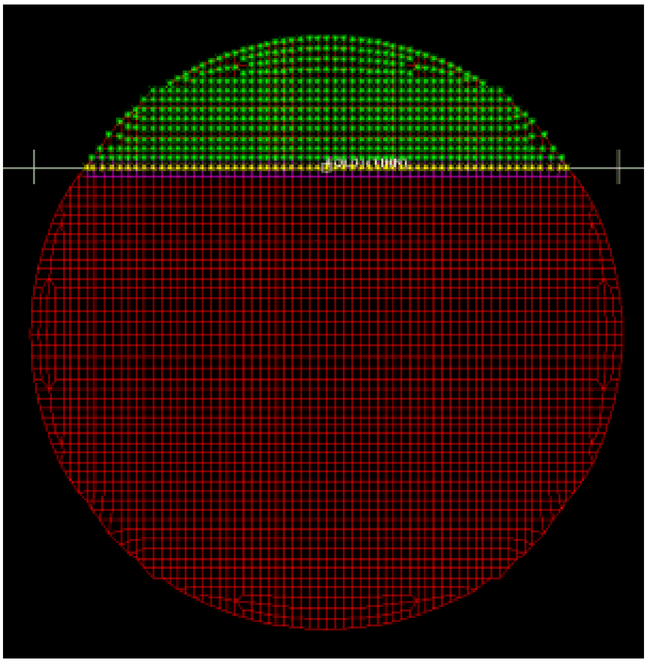




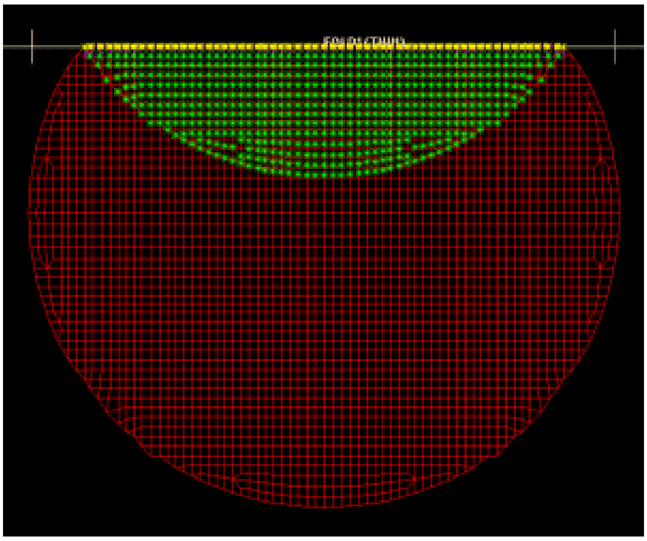
Fold nodes shown for a 0º fold from right to left.

Fold nodes shown for a 90º fold from top to bottom.

Changing any fold parameter such as the fold point, fold direction, fold angle automatically updates the display.



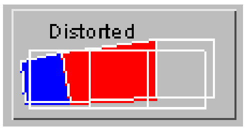
90º fold after changing fold point

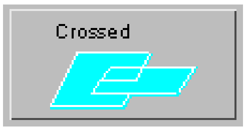


90º fold after applying thin fold

Automatically drawing the fold nodes can be turned off by using the folder options (see section 6.1.11). At any time the fold nodes can be redrawn by using the **FOLD NODES** button.

Crossed and distorted element plotting





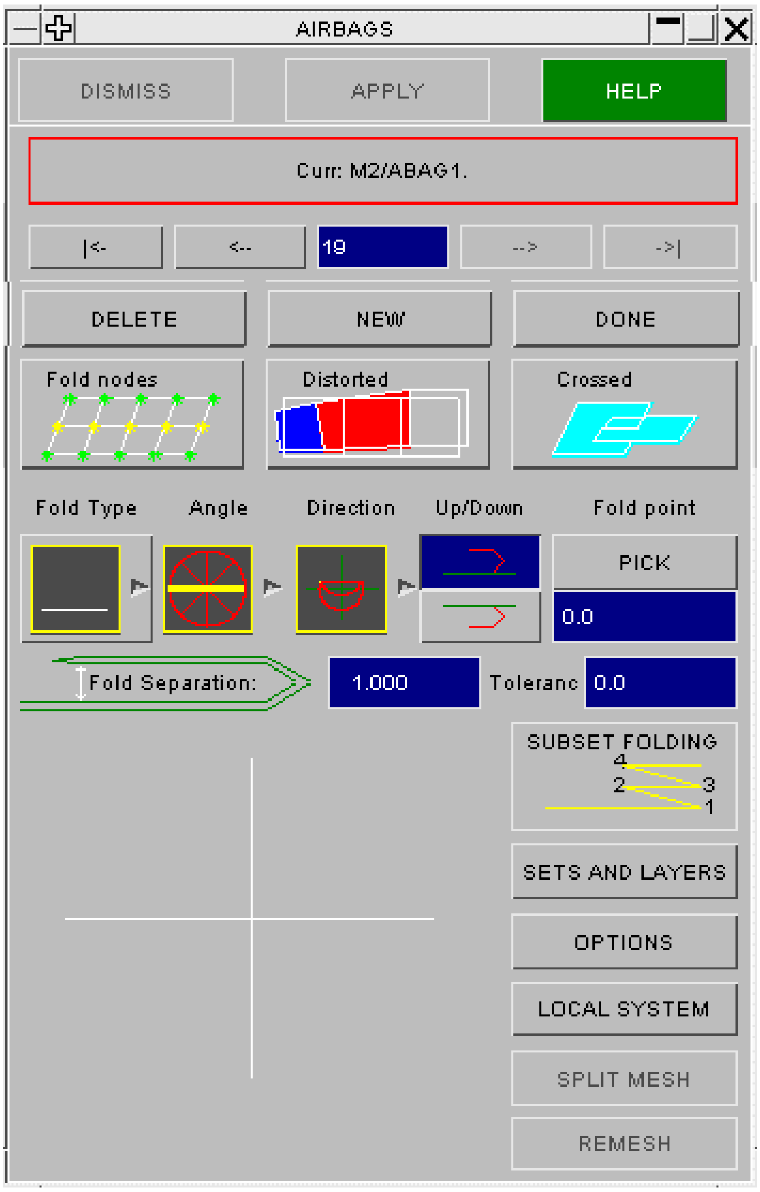
By default when doing a fold, elements which are distorted in the folding process and elements which have penetrations or are crossed are highlighted on the fold set. Just as with the fold nodes in the previous section, when any fold parameters are changed the display is automatically updated.

Automatically drawing of crossed, penetrating and distorted elements can be turned off by using the folder options (see section 6.1.11). At any time the elements can be redrawn by using pressing the **DISTORTED** and **CROSSED** buttons.

Elements are crossed when a node from one element has passed through the mid plane of another element. Elements are defined as penetrating if a node from one element is within the thickness of another element but has not passed through the mid plane. These features are very useful when adjusting the tip scale factors for thin folds. As the fold tip is adjusted the display will show if there are any penetration problems. In this way any potential penetration problems can be visualised and fixed. The thickness which is used for the penetration check can be altered in the folder options (see section 6.1.11).

Element distortion is defined as the ratio of the current element side or diagonal length divided by the reference element side or diagonal length. Therefore if an element is stretched the number will be greater than 1. If the element is shrunk the number will be less than 1. Three different contour bands are available for plotting distorted elements. The ranges and the colours for each contour can be altered in the folder options (see section 6.1.11).

6.1.8 SET_FOLD Creating Fold Definitions



Pressing **SET_FOLD** in the main folding window invokes the folding menu in the adjacent figure.

The fold number is adjusted by the **|< ... >|** buttons.

Fold control and saving are controlled here.

Fold node, distorted and crossed element plotting buttons.

The current fold type (null, thin, etc.), fold angle, fold direction, fold orientation and fold location.

The default/fold thickness and tolerance are set here.

Subset folding button

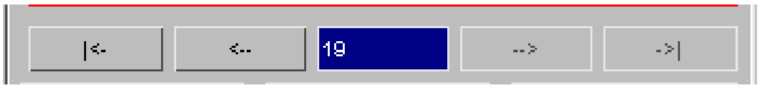
Sets and layers (section 6.1.10)

Airbag folder options

Local coordinate systems

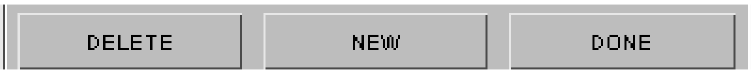
Mesh independent folding

Selecting the current fold number



The currently active fold is set via the buttons or text box in this region. In the figure above fold zero is shown, which implies "the whole fold set", and which allows you to set values for the whole airbag. Once finite fold ids (in this example #3) are shown, then operations apply to that fold only.

Controlling fold progress



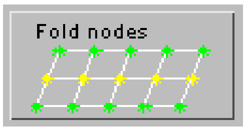
DELETE Deletes the current fold definition. All folds above this one have their number decremented by one.

DONE Finishes the folding process and returns the user to the main FOLDING menu.

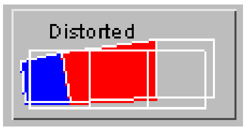
NEW Creates a new fold. If used in the middle of a sequence a new fold is inserted between the previous and next folds, and all folds above this point have their number incremented by one.

Viewing fold node and element information

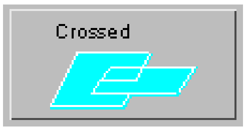
FOLD_NODES Redraws the fold nodes at any time. By default this is done automatically but if this is turned off with the folder options this button can be used



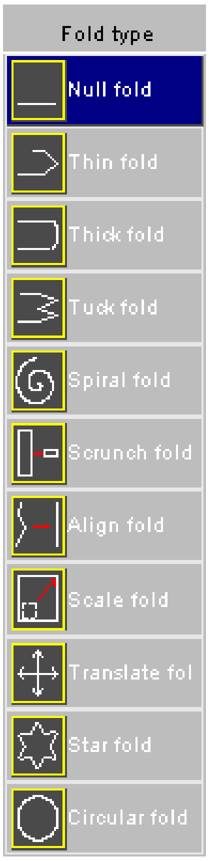
DISTORTED Redraws the distorted elements at any time. By default this is done automatically but if this is turned off with the folder options this button can be used to plot the distorted elements.



CROSSED Redraws any crossed elements. By default this is done automatically but if this is turned off with the folder options this button can be used.



Selecting the current fold type



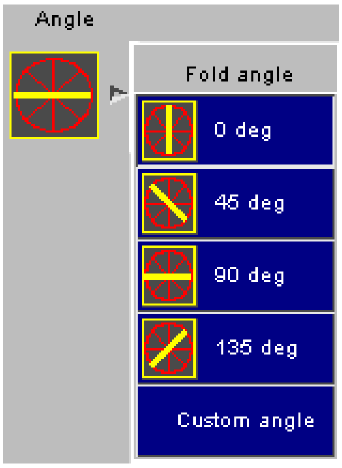
The **Fold Type** popup button controls the current fold type, which will be one of

- Null fold
- Thin fold
- Thick fold
- Tuck fold
- Spiral fold
- Scrunch fold
- Align fold
- Scale fold
- Translate fold
- Star fold
- Circular fold.

In this example a "thin" fold is current, but the type can be changed dynamically by simply selecting a new type with the popup menu. More information about each fold type is given below in section 6.1.10. Star and circular folds are unavailable from this menu. These are selected to be created from the initial airbag start up screen. For more information on these types see Creating and Folding a new airbag.

The fold type button will toggle between the currently selected fold type and a null fold.

Setting the Fold Angle



The Angle popup button can be used to select the angle of the fold. In this diagram the current fold angle is 90º . The popup contains default fold angles of 0, 45, 90 and 135º . Most folds will take place in either the X (0º) or Y (90º) directions, but if necessary, you can use Custom angle to set the fold to an arbitrary angle.

If a new fold angle is chosen the graphic on the Angle button will be updated so you can easily see the angle of the current fold.

Defining an arbitrary XY fold angle using Custom angle

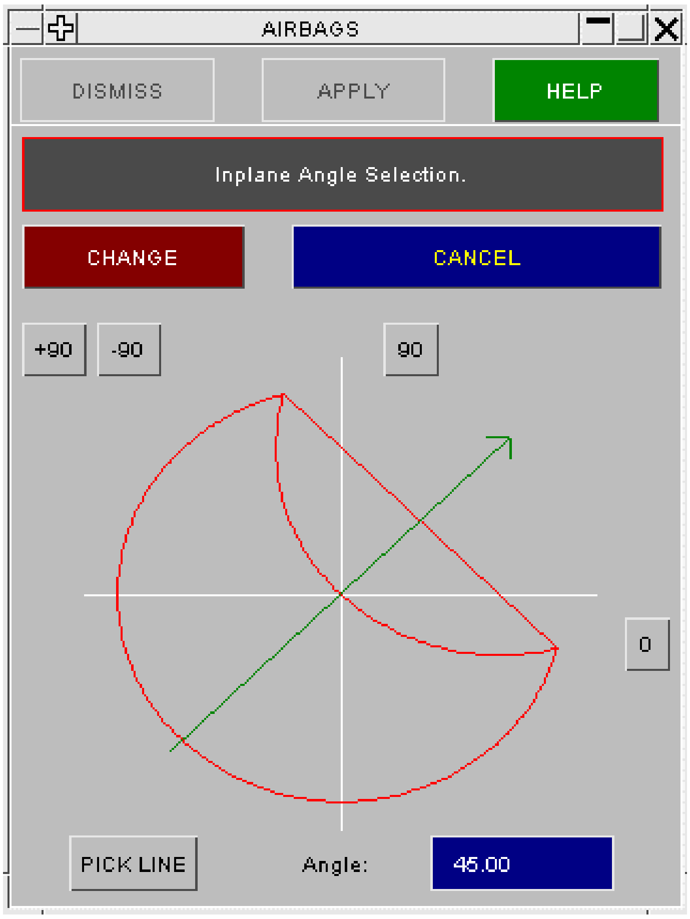
The adjacent figure shows the box after pressing Custom angle. This allows the user to define an arbitrary fold line.

The angle may be selected in either of the following ways:

PICK LINE Calculates a line, and hence an angle from two screen-picked nodes.

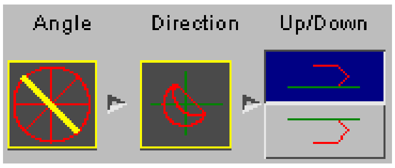
Angle: Accepts a typed in angle, which may also be modified by **[0]**, **[90]**, **[+90]**, **[-90]**.

To accept the current definition press **CHANGE**, which will return to the fold definition menu.



Angle: 45.00

Setting the Fold Direction



As well as setting the fold angle, the direction in which the fold is done needs to be set. In the adjacent figure the fold angle is set to 45º (you can tell this because of the angle of the yellow line). The graphic shown for the direction of the fold is also drawn at the 45º angle but there are two possible ways to do this fold

The upper right part of the airbag can be folded onto the lower left part of the airbag (**Forward**).
The lower left part of the airbag can be folded onto the upper right part of the airbag (**Reverse**).

You can select the fold direction by choosing either Forward or Reverse. The graphic on the **Direction** button will change to indicate your selection.

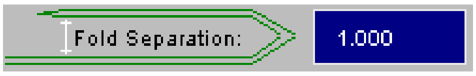
Setting the up/down direction

When a fold is done the folded material can either be folded on top of or underneath the unfolded material. The Up/Down buttons are used to set this.

Folded material is folded on top of unfolded material.

Folded material is folded underneath unfolded material.

Setting fold separation distance

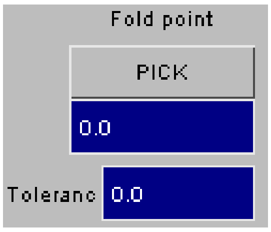

Fold Separation: 1.000

When a fold is current this sets the distance between layers, the thickness.

If fold #0 is current, this sets instead the Default Thickness to be used for all folds in the airbag, which may be overridden for individual folds.

When folding takes place the larger of the default and individual fold thicknesses is used, so a useful way to visualise an airbag is to set the individual fold thicknesses to their correct, relatively small, values; but to set the default thickness to a larger value, so making it easier to view folds. When folding is complete the default value can be reset to a more realistic value.

Setting the FOLD_POINT and Tolerance



0.0
Toleranc 0.0

The fold point identifies an XY coordinate through which the fold line passes. This can be defined by using **PICK** to screen-pick a node, or by typing in an explicit value (which is a distance down the relevant axis). For thin and tuck folds this point should lie on, or be very close to, a node; for other fold types any reasonable location may be chosen.

Tolerance defines the tolerance margin either side of the fold line used when searching for nodes that lie on the line. You should aim to choose the smallest value that will include all nodes on the fold line.

6.1.9 SETS AND LAYERS Selecting a subset of the airbag for folding

By default the whole fold set is considered for folding when a fold is defined. Sometimes you do not want to fold the entire airbag. For example, if you have done several folds already, on your next fold you may only want to fold the top layer of the airbag rather than the whole airbag. Sets and layers are used to select which bit of the airbag you want to fold. They work in different ways. Normally you will only need to use one or the other but both can be used together if needed.

Using Sets

A set is a collection of shells from the fold set. If a set is defined then rather than folding the entire fold set, just the shells in the set will be considered for folding. The set could contain a single shell from the fold set or it could contain the whole fold set.

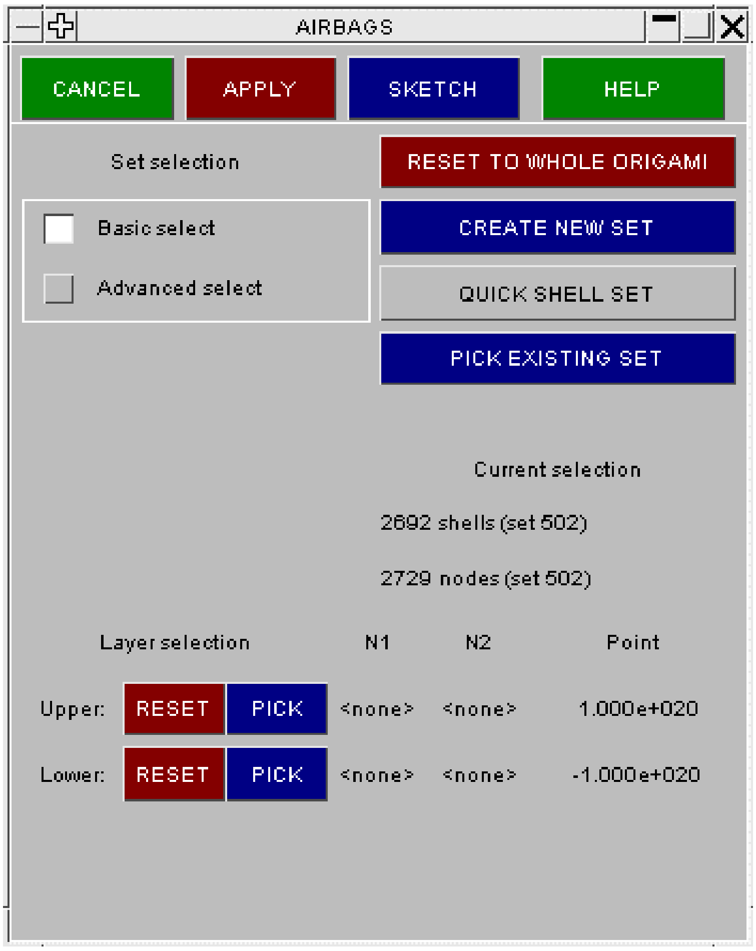
There are two methods for selecting sets: **Basic select** and **Advanced select**. It is strongly recommended that you use **Basic select** as this is much simpler. If this cannot do what you need (which is unlikely) then use the **Advanced select** option.

The sets works by using sets of shells. These can be created inside the airbag folder, or if your model contains sets already they are available for use. To pick an existing set use the **PICK EXISTING SET** button. You can then choose from the list of available sets.

To see the current set selection you can use the **SKETCH** button. This will sketch which shells are in the set on the graphics window. You can reset the selection to the whole fold set by pressing **RESET TO WHOLE ORIGAMI**.

To create a new set you can use **CREATE NEW SET**. This will start the standard set creation panel. Once the set has been created it will automatically be chosen for folding.

Alternately you may use **QUICK SHELL SET** to create the set at highest label + 1.



Current selection

2692 shells (set 502)

2729 nodes (set 502)

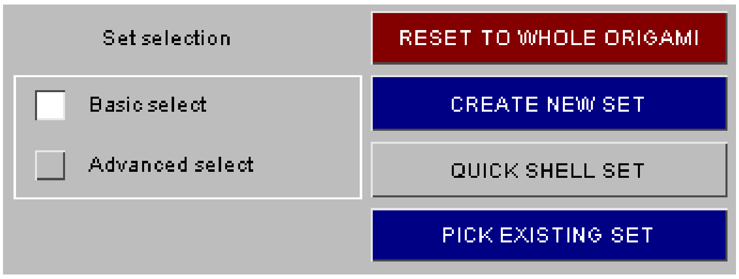
Layer selection			N1	N2	Point
Upper:	RESET	PICK	<none>	<none>	1.000e+020
Lower:	RESET	PICK	<none>	<none>	-1.000e+020

It is important to realise that just because a shell is in a set does not mean that it will definitely be folded. The shells that are in the set are the ones that will be considered for folding. As an example consider the first fold of an airbag where we have defined the set to be the entire fold set. When the fold is actually performed the folder checks all the shells in the set. Some of these shells will be on the wrong side of the fold line and will be left in their original positions. Only the ones which are on the correct side of the foldline are actually folded. So even though all the shells were considered for folding, the folder actually only folded the shells on the correct side.

Quick set creation

The **QUICK SHELL SET** button allows you to create a shell set in a much quicker way than the normal creation method.

A shell set is automatically created for you with the next free label.

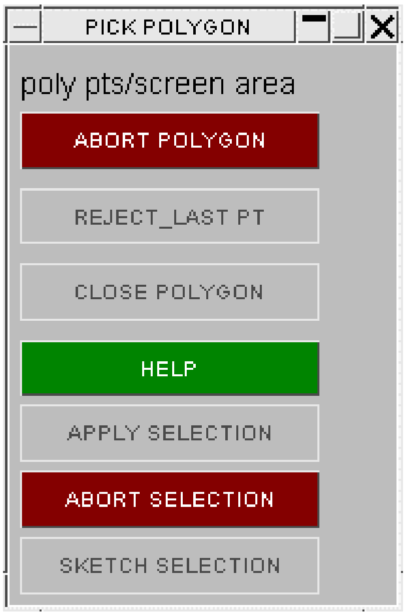


Shells can be added or removed from the set by the following methods

1. Clicking and dragging with the left mouse button will add shells to the set by box.
2. Multiple left mouse button clicks will add shells to the set by polygon.
3. Clicking and dragging with the right mouse button will remove shells from the set by box.
4. Multiple right mouse button clicks will remove shells from the set by polygon

To finish selecting the shells and create the set, press the **APPLY SELECTION** button.
When selecting by polygon, if you close the polygon by clicking back onto the first point, the shells will be added.

Alternatively you can press **CLOSE POLYGON** to select the shells. **REJECT LAST PT** will delete the last point in the polygon. **ABORT POLYGON** will restart the polygon.



Advanced set selection

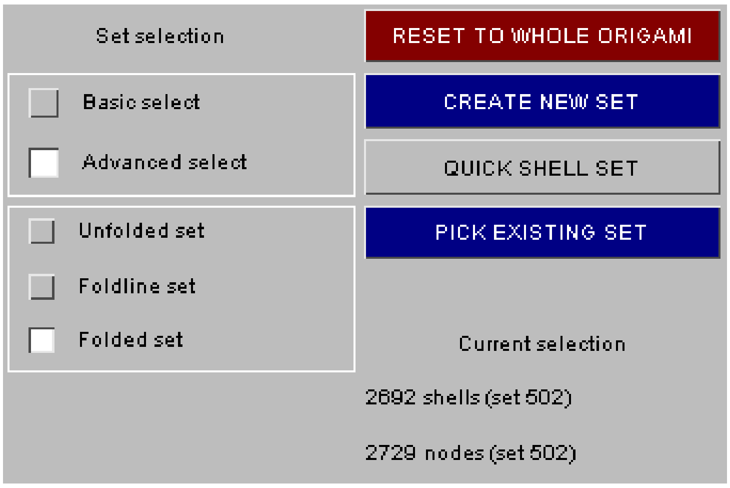
The advanced set selection works with sets just like the basic set selection. The difference is that instead of using a single set (basic select), 3 sets are used.

When a fold is performed there are three distinct regions of the fold.

The **Unfolded set**. The shells that will not move. i.e. they will be unaffected by the fold.

The **Foldline set**. The nodes which are actually on the fold line.

The **Folded set**. The shells that will be folded. i.e. the shells that will move during the fold.



2692 shells (set 502)

2729 nodes (set 502)

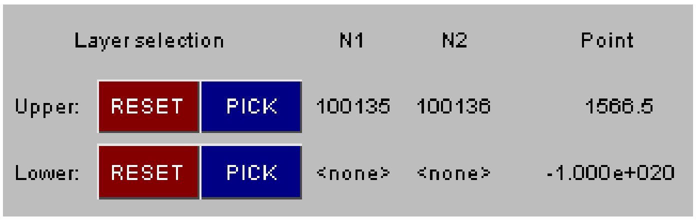
Each of these 3 sets can be selected individually. They can be completely different sets.

It is important to realise that the logic from the basic selection method still applies here. The folded set contains the shells that will be considered for moving during the fold. The foldline set contains the shells (actually the nodes from these shells are considered) that will be considered for the fold line etc.

In actual fact the basic selection method works by setting all 3 sets to be exactly the same. It is then the folder which works out which shells should be folded, which should be left in place and which nodes are on the fold line.

Layers

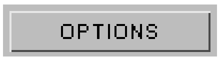
By default all layers (through the thickness of the airbag) will be folded, but sometimes it is convenient to restrict this to only layers within a given +/- Z coordinate.



Layer selection			N1	N2	Point
Upper:	RESET	PICK	100135	100136	1566.5
Lower:	RESET	PICK	<none>	<none>	-1.000e+020

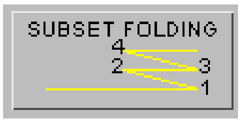
Upper and Lower layer selection define respectively the upper (positive) and lower (negative) Z limits within which material will be folded. Selecting **PICK** from either prompts you for two nodes, and the Z limit used is set to the average of these. (The reason for having two nodes is that you need to define a point between the outermost layer to be folded, and the layer beyond that, and usually there will only be empty space there!). The default values that are used for the upper and lower limits are 1.0e+20 and 1.0e-20 respectively so by default the whole fold set (or set) will be folded. **RESET** can be used to set the lower/upper layer back to this default. In this example the upper layer is 1.0e+20 and the lower layer is -0.3 so anything which is less than Z=-0.3 will not be considered for folding.

Airbag Folder options



Various options can be set for the folder. See section 6.1.11

Subset Folding



Subset folding can be used to quickly create folds. See section 6.1.10

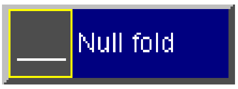
Fold Creation

The following process should be followed to create folds:

1. Create a **NEW** fold. By default a point point at 0 and left-right folding is done.
2. Fold angle: Set the fold angle by using the popup button to choose one of the preset angles or a custom angle. As you change the angle, the highlighted nodes on the screen change.
3. Fold direction: Decide on whether material is being folded in the forward or reverse direction. As you change the direction the highlighted nodes on the screen will change accordingly.
   Decide on whether folded material should finish above or below unfolded material. The top of the bag is defined as being in the direction of increasing Z.
4. Select material to be folded if necessary: ie define **Upper** or **Lower** layers and/or a set in the **SETS AND LAYERS** menu. As you change the layer or set selection the highlighted nodes on the screen will change accordingly.
5. Decide on the fold type (**Thin**, **Thick**, etc) - see Section 6.1.9.
6. On pressing the fold type required FOLDER folds the FOLD SET. This may require adjustment of parameters (Separation, Tolerance) to achieve a good result.
7. Continue creating new folds until the complete FOLD SET is folded.

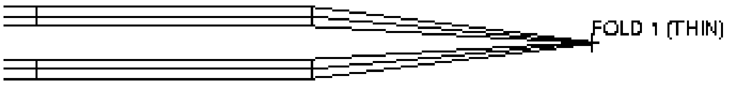
6.1.10 Fold types

Null Fold (Set attributes, but don’t fold mesh)



The **NULL** fold allows the user to define all the fold data without actually folding the FOLD SET. This is useful when the current fold appears to be incorrect (eg too many layers have been folded). Pressing the NULL fold option effectively unfolds the current fold and allows the user to change the fold parameters (eg entity selection). The nodes which will be folded are still highlighted

Thin Fold (Perform a sharp "crease" fold)

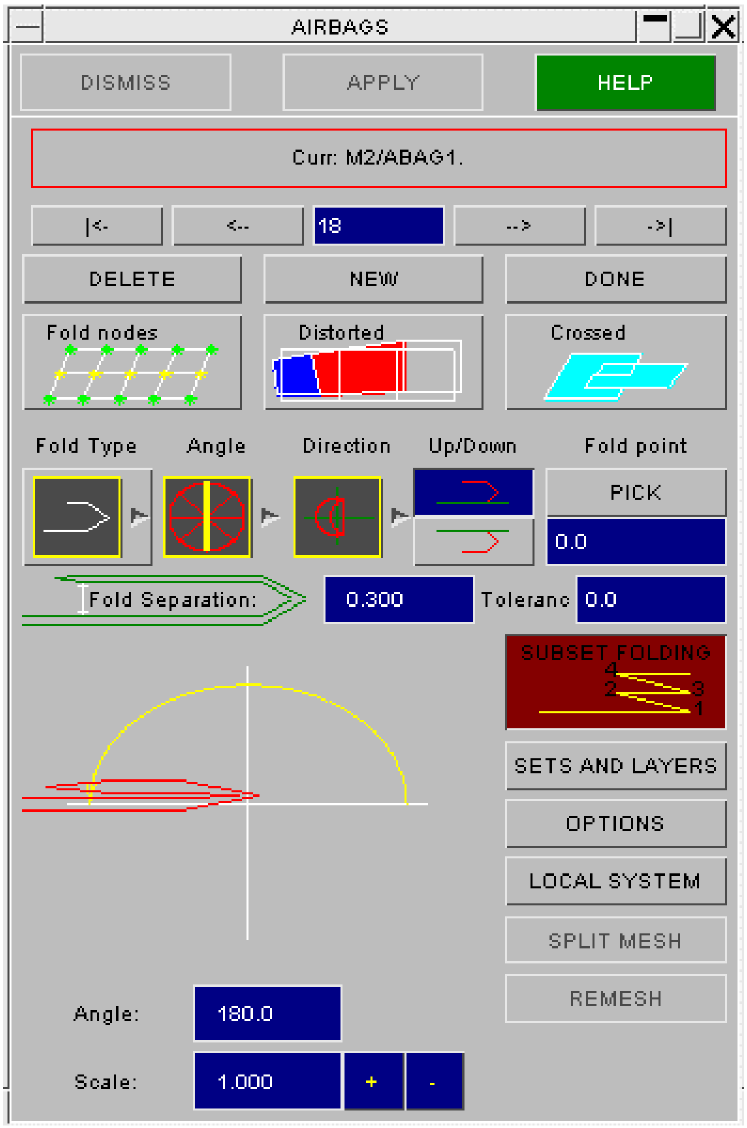


For airbags, the most common fold type is the thin fold. Material is creased sharply along a line of nodes to give a precisely defined shape.

The definition and control panel for **thin** folds are shown in the figure below:

The panel shows the creation of a thin fold. the airbag has been folded from right to left - the right hand side ending up on top of the left hand side. The fold thickness is 0.3.

Typical thin folds, have a total fold angle of 180º with the centre portion rotated 90º though this is not a requirement. Angles larger than 180º are not permissible. These defaults are being used here. The thin fold graphic above shows that there is some pinching at the fold tip. The pinching can be reduced by increasing the **Scale** option to spread the layers at the fold tip.



Curr: M2/ABAG1.

18

Fold point: 0.0

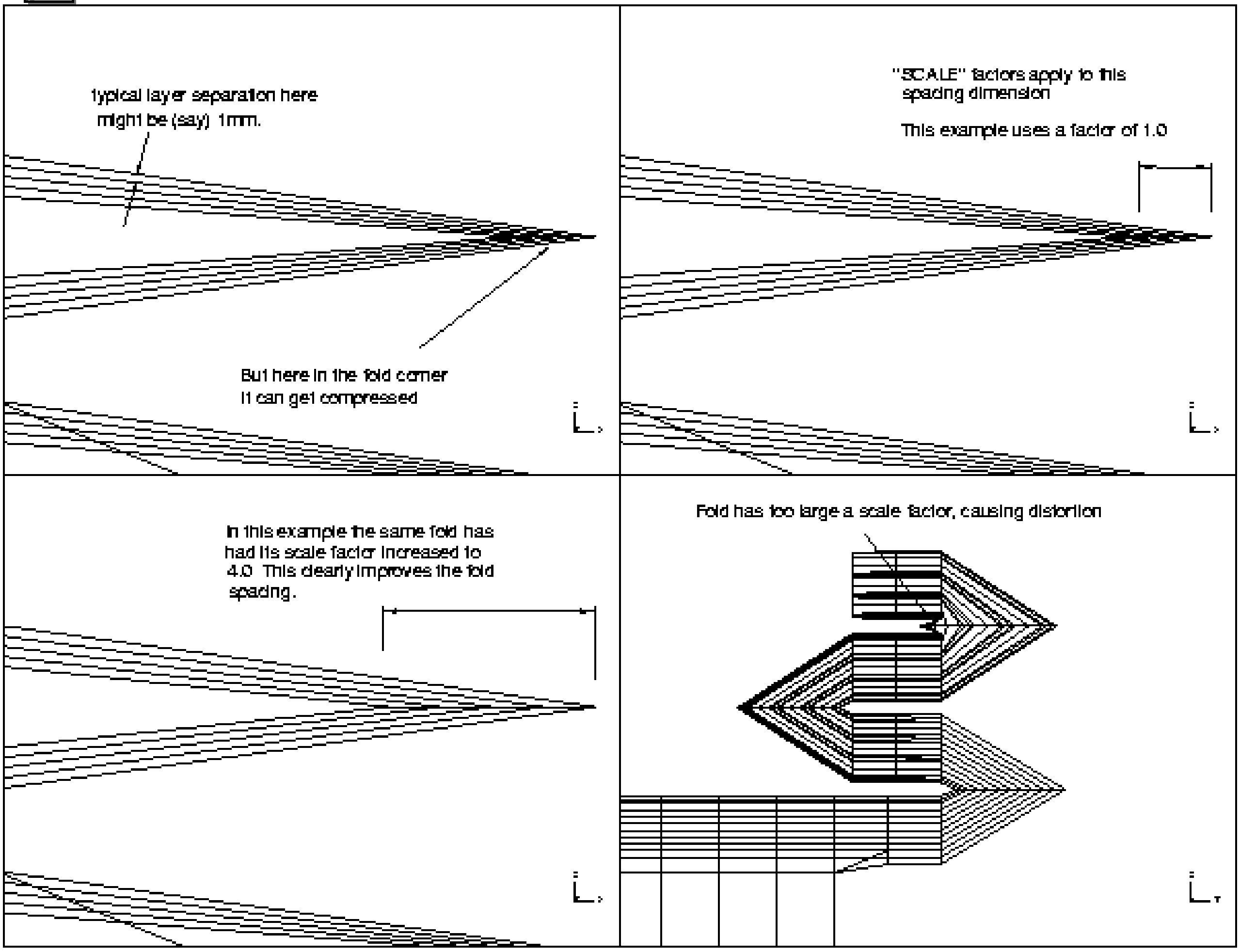
Fold Separation: 0.300

Toleranc 0.0

Angle: 180.0

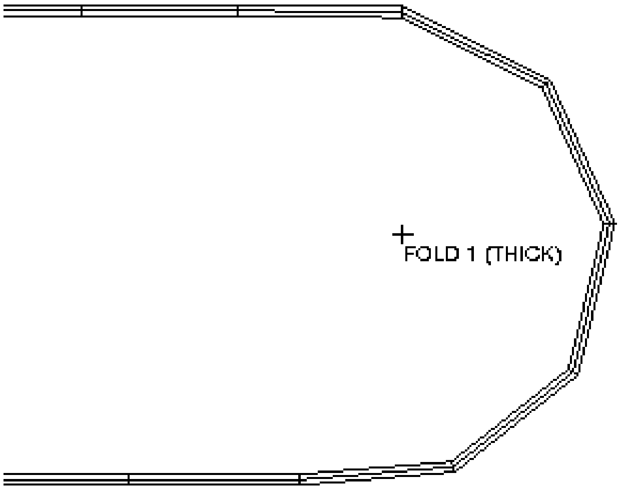
Scale: 1.000

The figure below shows the effect of **Scale** on typical thin folds. It is generally desirable to try to select a value which causes the inner and outer material surfaces to be parallel, as this will lead to the contact algorithms being more reliable. However, the user should take care that this doesn't lead to gross local element deformations: as in the bottom right quadrant of the figure. This can also be visualised by using the **CROSSED** element button. If there are problems with element penetrations this will easily show it. Changing the scale factor will automatically update this plot so you can tell when any penetrations are eliminated.


typical layer separation here
might be (say) 1mm.
But here in the fold corner
it can get compressed
"SCALE" factors apply to this
spacing dimension
This example uses a factor of 1.0
In this example the same fold has
had its scale factor increased to
4.0 This clearly improves the fold
spacing.
Fold has too large a scale factor, causing distortion

By default all the elements and nodes selected for the Fold Set definition are included in the fold, but it is possible only to operate on a sub-set of these. The **SETS AND LAYERS** button can be used to select a subset to fold

Thick Fold (A radiused fold spanning > 1 element)

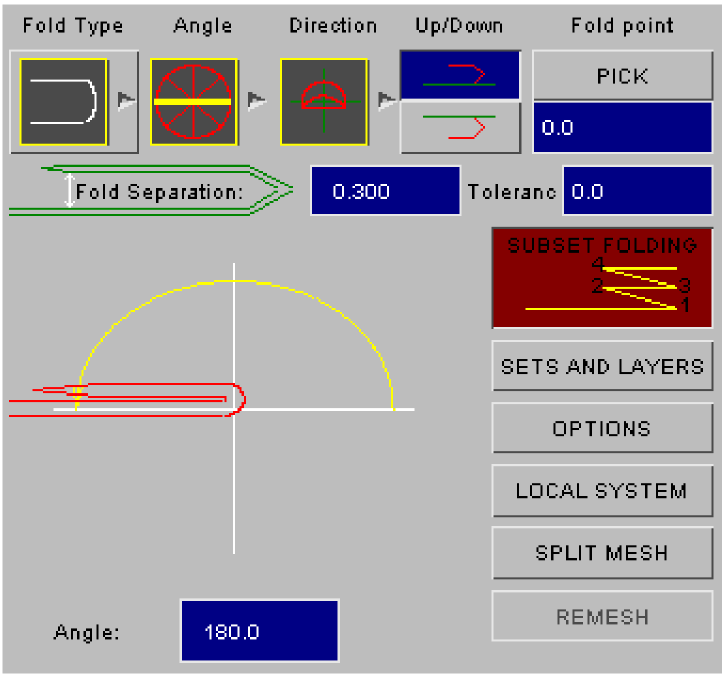


Thick folds are used when the mesh is extremely fine or when there are a large number of layers to be folded. In general the element size should be smaller than the fold radius or it is unlikely that a satisfactory fold will be created.

As this figure shows the effect is to create a radiused fold, using several elements, giving an effect similar to rolling the mesh round a circular former of the given radius.

The adjacent figure shows the fold creation menu - the material has been folded from bottom to topand the folded material is folded on top of the unfolded material. The only option which is available for a thick fold is the angle. In this figure the angle is set to 180º . The thick fold does not have a precise centre like the thin fold, but it does allow for arbitrary angles of orientation.

Usually, a fold point is located towards the packaging limits of a airbag. In this fold, the fold point is offset ahead of the centre point for the fold by the radius. The radius is equal to half the separation distance between layers. If more precise control over the selection of elements for this fold is needed, then the **advanced set selection** option in **SETS AND LAYERS** can be used to select the portion of the airbag to be folded. The **unfolded** set is used only to determine clearances in this fold type.


Fold point: 0.0

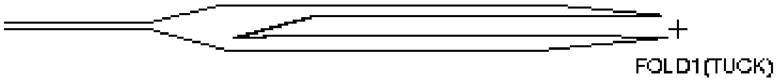
Fold Separation: 0.300

Toleranc 0.0

Angle: 180.0

Tuck Fold (A thin fold tucked into the mesh centre)

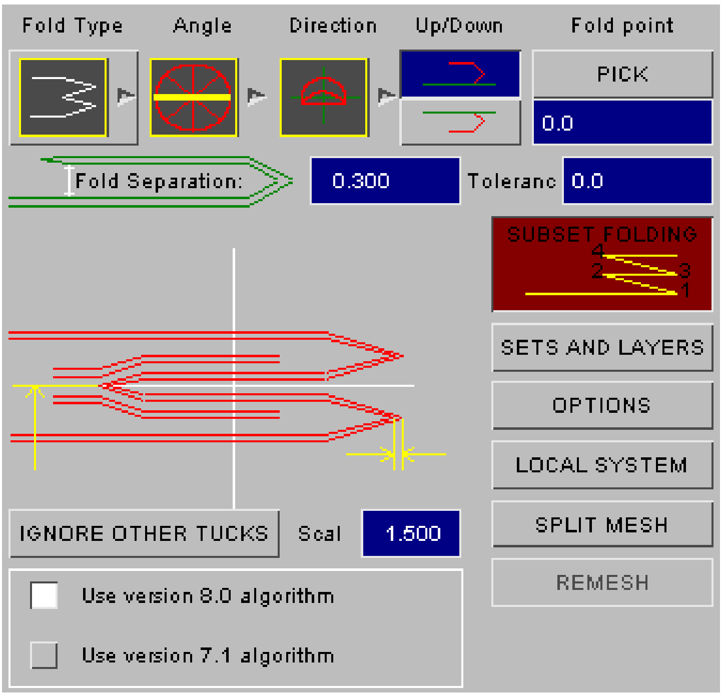
Tuck fold



The tuck fold is also common in airbags. The material is folded inside the outer layers to form a "tuck". ("Up" and "Down" have no meaning here.)

The adjacent figure shows the tuck fold creation panel.

In version 8.0 a second tuck fold algorithm has been added. This is not meant to replace the version 7.1 tuck fold as there will be situations when the version 7.1 fold will perform better than the version 8.0 tuck fold. However the new version 8.0 tuck fold will perform much better in situations where two tuck folds interfere with each other. To illustrate the point the next two figures show an cross section through an airbag with 2 interfering tuck folds (one from each side of the bag) folded with the version 7.1 tuck fold and the version 8.0 tuck folds.



Fold point: 0.0

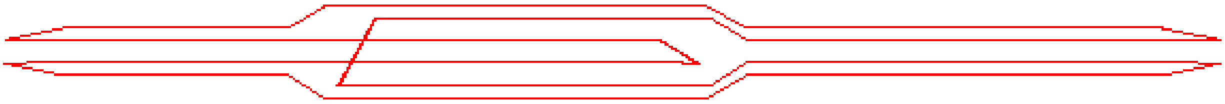
Fold Separation: 0.300

Toleranc 0.0

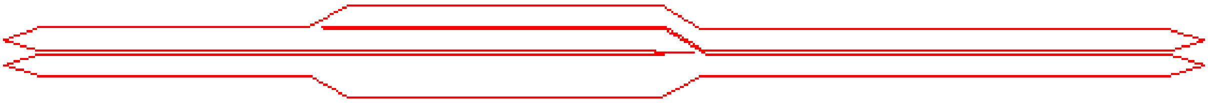
Scal 1.500

□ Use version 8.0 algorithm

□ Use version 7.1 algorithm



Two interfering tuck folds using the version 7.1 tuck fold algorithm

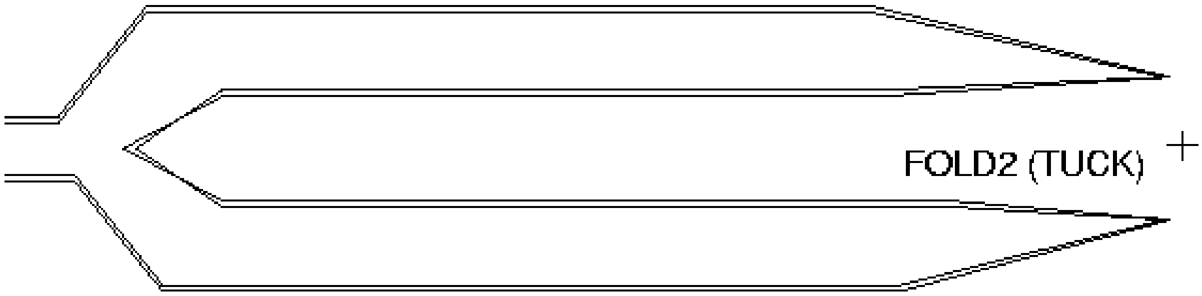


Two interfering tuck folds using the version 8.0 tuck fold algorithm

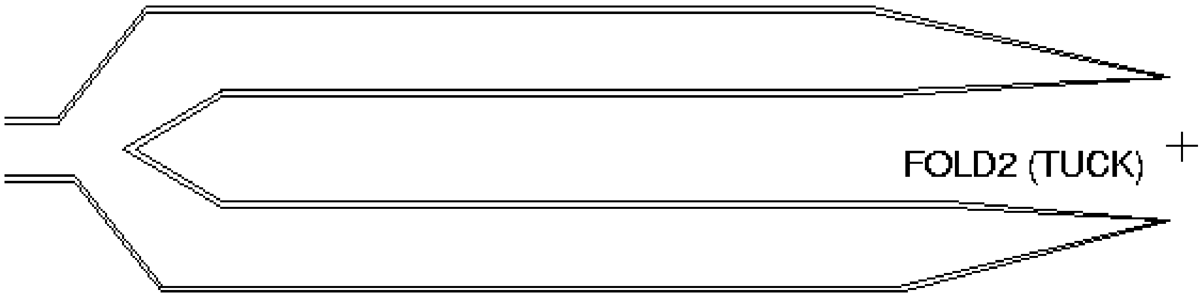
The tuck folds using the version 7.1 tuck folds penetrate through each other. If this airbag was deployed there would be problems with contacts and the airbag forming knots. Additionally the nodes on the fold tip are not in the correct place. The version 8.0 folds do not penetrate through each other and so this airbag will deploy correctly and the nodes at the tip of the fold are still in the correct position.

The default for tuck folds is to use the version 8.0 algorithm. If the fold cannot be performed with this algorithm you can still use the older 7.1 algorithm. This may be better for tuck folds which use multiple material thickness as there are some additional options which may help.

The following two figures illustrate the use of these options for the version 7.1 algorithm, the left hand figure shows that problems can occur with penetrations when using tuck folds for multiple layers. If problems occur then selecting **[>>]** (double layer mode) may help resolve the problem (right hand figure). But, the double layered mode is only valid if the fold tip lies along a line of nodes. If it does not then the single layered mode should be used.



Penetrations at tip

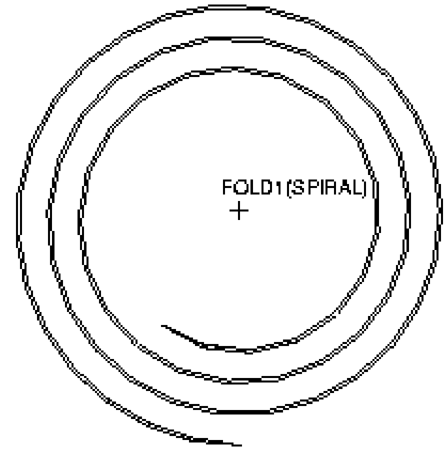


No Penetrations

By default, the folder attempts to locate the middle fibre of the unfolded material. Everything above the middle fibre is pushed up and everything below the middle fibre is pushed down so that the tip can be inserted and clearance maintained. This can be overridden if FOLDER selects the wrong location using **ZSPLIT** which prompts the user to pick two nodes. These define a plane whose normal vector starts mid-way between these nodes. The layers are then separated above and below this plane.

SCALE allows the user to reducing the pinching that occurs at the fold tip by increasing the node separation.

Spiral Fold (Rolling layers into a spiral)



The Spiral fold is used to roll up a flat bag.

An Archimedean spiral (radius is proportional to angle) is used, and FOLDER attempts to keep the characteristic element length constant at the middle fibre of the bag.

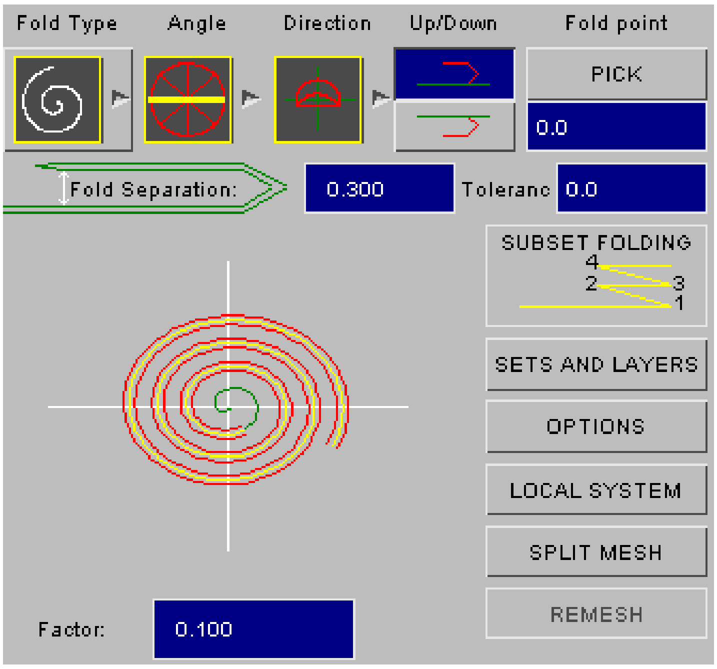
The adjacent figure shows the fold definition and options menu for the spiral fold.

Controlling the spiral internal radius

FOLDER tries to preserve a constant arc length for the middle fibre of the bag as it is rolled, which presents problems at the spiral centre where the radius tends to zero and will always be smaller than the elements.

In practice a rolled airbag has a finite thickness and therefore will not use the early portion of this curve. FOLDER uses a **Factor**, of the original arc length of the airbag to specify that portion of the curve that is not to be used. For example, a Factor of 0.5 increases the total arc length to 1.5 times the airbags arc length and leaves the first 0.5 times this arc length unused. A factor of 0 would have no unused portion and the airbag would be rolled from the spiral centre. The options menu shows how much of the spiral is mapped and how much is unmapped. The default factor is 0.1.

The user can also specify a subset of the airbag to be folded using the **SETS AND LAYERS** options as for other types.



Fold point: 0.0

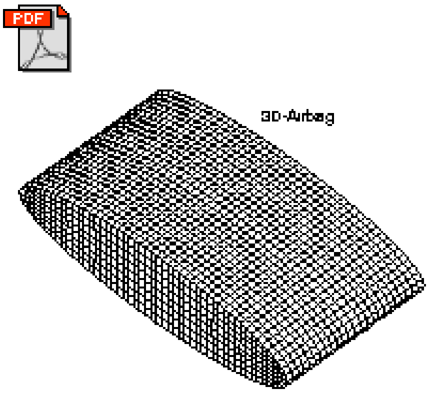
Fold Separation: 0.300

Toleranc 0.0

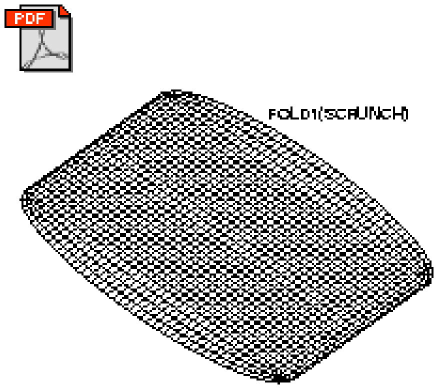
Factor: 0.100

Scrunch Fold (Compressing a 3D bag to a flat shape)

Scrunch fold



Before scrunch



After scrunch

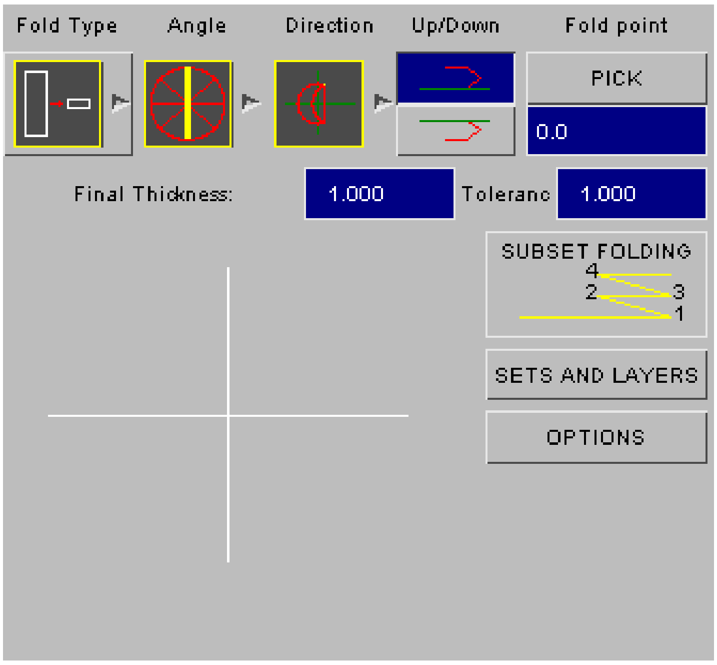
The adjacent figures show a 3D airbag being **scrunch**ed to a flat (2D) shape.

The option of splaying the sides out has been used.

This fold type can accomplish two separate functions:

1. It can simply scale an existing bag in the local Z-direction so that it has a smaller final thickness.
2. It can flatten a 3D airbag so that the 2D folder (thin, thick etc) can be used. The bag is reduced in the Z-direction and the sides are pushed out.

The **scrunch** fold definition and options are shown in the adjacent figure.



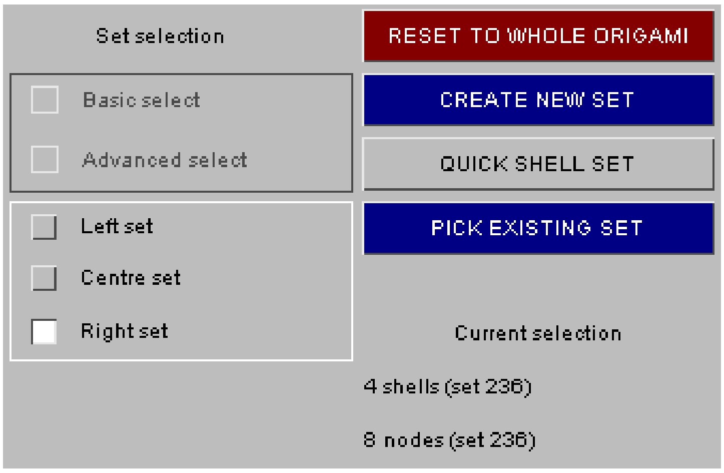
Fold point: 0.0

Final Thickness: 1.000

Toleranc 1.000

The user must tell FOLDER which elements form the side to be pulled out. This is done using the **Left** and **Right** sets from the **SETS AND LAYERS** menu. If neither of these sets is chosen, then a simple scaling is used. In the case shown above this could lead to the vertical elements having a zero side length (which may not be illegal if airbag reference geometry is used during the analysis).

When forcing the sides outwards, the top and bottom of the bag are located above and below a side node. The node is then pushed outwards based on the nearest distance to the top or bottom. When using this capability for pushing out side walls, it is important how the bag is oriented. The axis of the cylinder must be parallel with the local X-axis. The sides must be in the YZ plane.



Current selection

4 shells (set 236)

8 nodes (set 236)

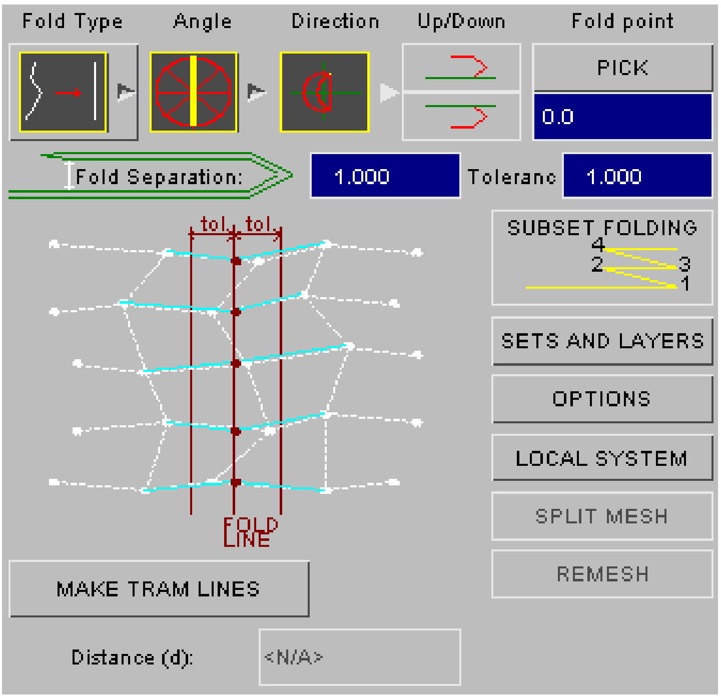
FOLD_POINT has no effect here the FOLD SET is scrunched about the local z=0 plane.

Align Fold (Aligning nodes on a fold line)

The align fold is used for projecting nodes onto a fold line. This is very useful if the nodes do not line up exactly on a fold line or if the fold line is in slightly the wrong position. The adjacent figure shows the align fold creation menu. In this example the **TRAM LINES** option has been set. This can be turned on or off by using the **MAKE TRAM LINES** button.

The normal options for selecting the nodes for the align fold can be used. You can select the nodes you want to fold using the **SETS AND LAYERS** options. Alternatively, you can use the nodes which were folded in the previous fold by using the **SUBSET FOLDING** option.

For both options you give a fold point and a fold angle to define the fold line. The nodes which will be aligned are highlighted on the screen. The **Tolerance** option can be used to increase the tolerance for selecting the nodes which will be moved onto the fold line.



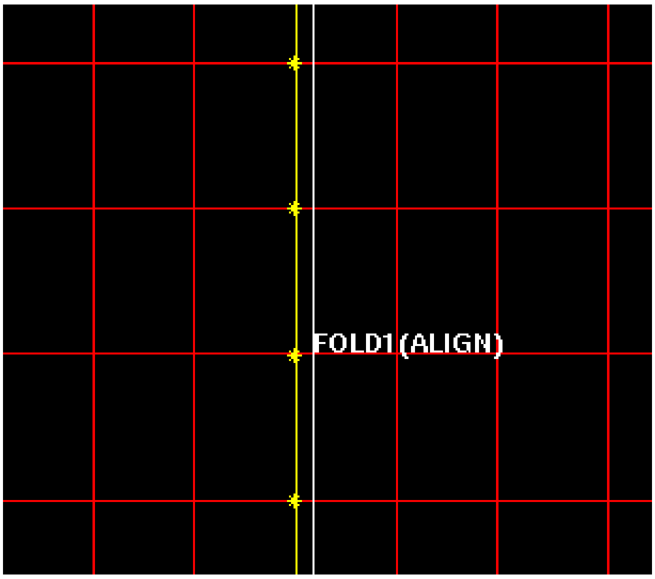
Fold point: 0.0

Fold Separation: 1.000

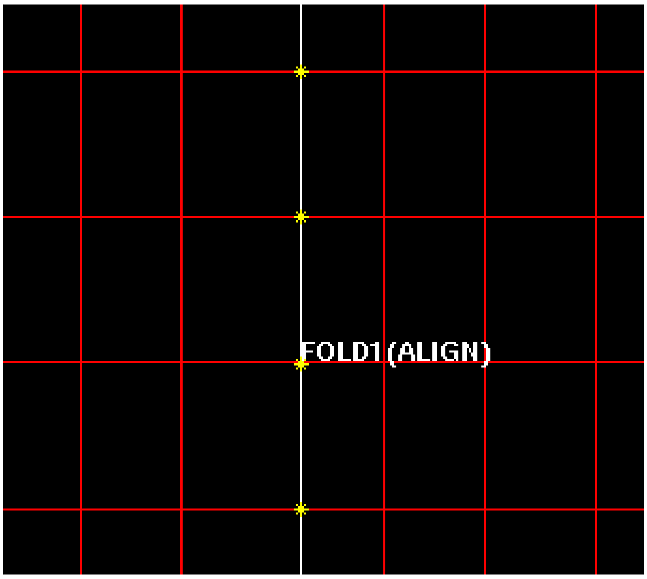
Toleranc 1.000

Distance (d): <N/A>

The default options for the align fold just move the selected nodes onto the fold line. The following figures show the effect of this option with pictures before and after the align fold.



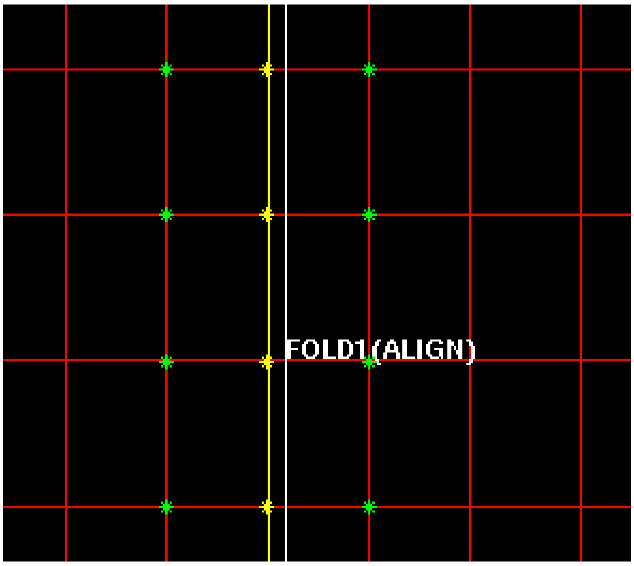
Before align fold



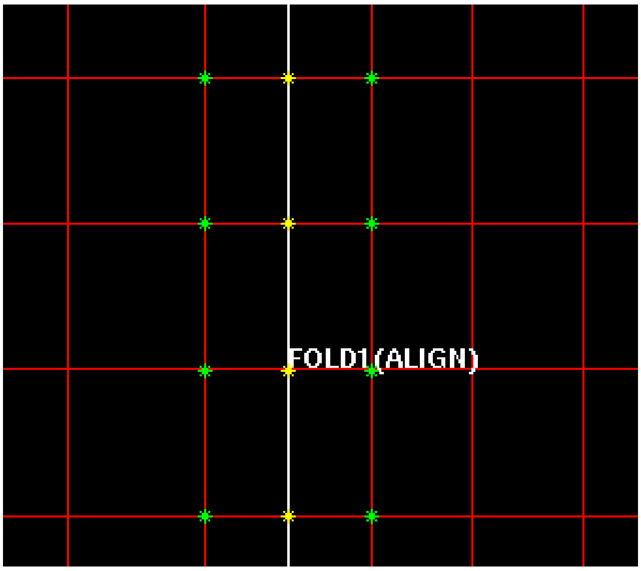
After align fold

Folds work best if the nodes adjacent to the fold line are a constant distance from the fold line. The **MAKE TRAM LINES** option does this. If the option is set then if a node from an element is moved onto a fold line the other nodes on the element which are not on the fold line will be moved to be a constant distance away. You can enter the distance to position the nodes with the **Distance** box. The diagram in the panel updates to show you that you are using the tramlines option.

The following figures show the effect of the tramlines option with pictures before and after the align fold.



Before align fold



After align fold

With the tramlines option set the adjacent nodes are a fixed distance from the fold line. Compare the above pictures to the ones with the tramlines option not set.

Scale Fold

Scale fold

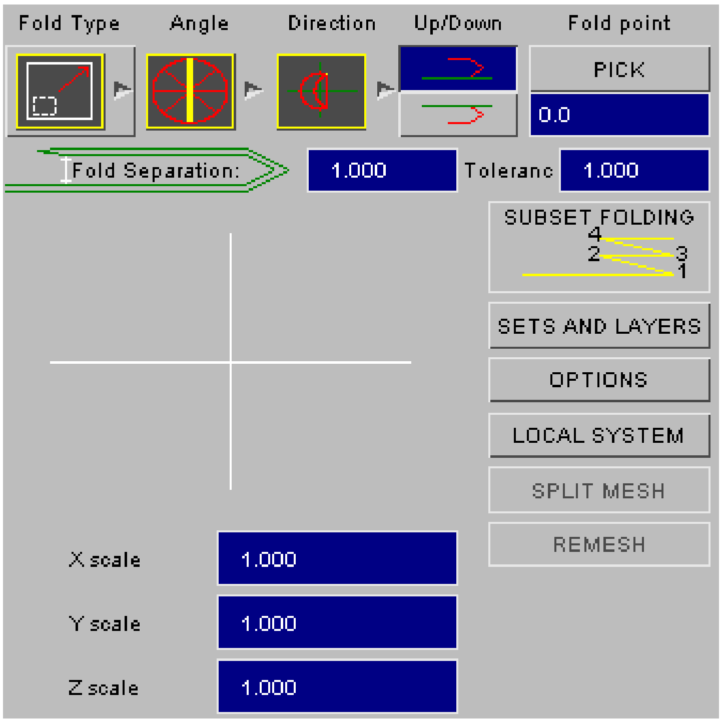
The scale fold is used for shrinking or enlarging parts of the fold set.

The scaling is done in the local co-ordinate system of the fold, NOT the global co-ordinate system.

To help you visualise the local co-ordinate system the axis triad is drawn on the airbag.

The nodes/elements that you want to scale are selected in the normal way using sets and layers as required.

You can give separate scale factors for the X, Y and Z axes of the fold.



Fold point 0.0

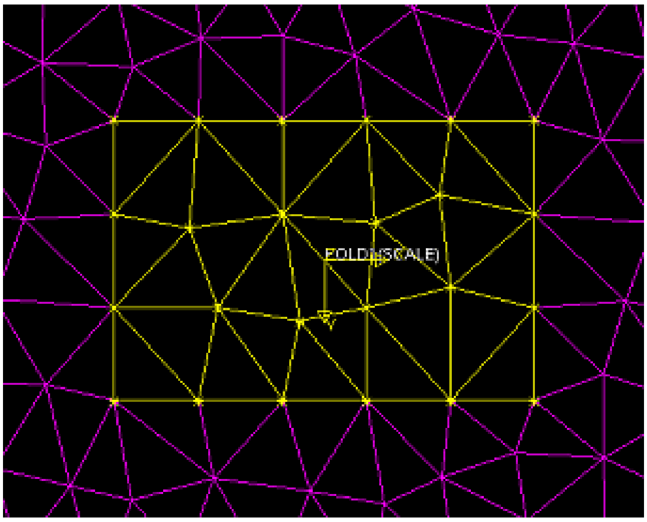
Fold Separation: 1.000 Toleranc 1.000

X scale 1.000

Y scale 1.000

Z scale 1.000

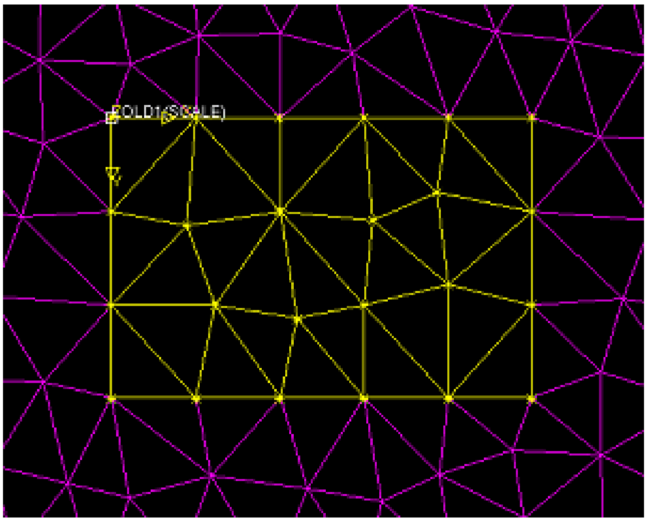
Examples of scale fold



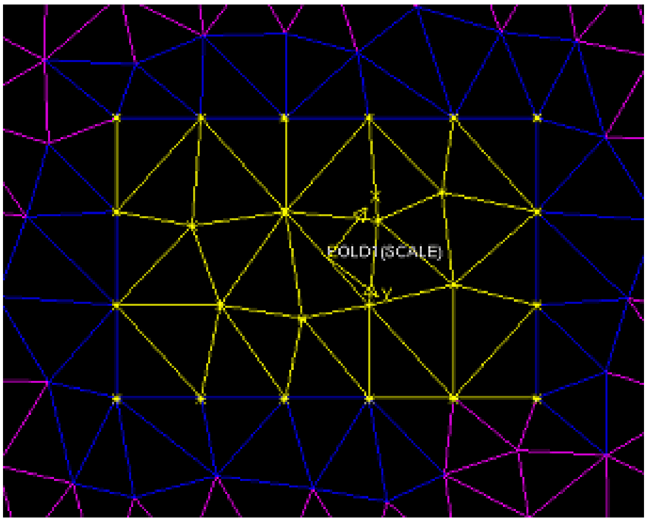
The yellow portion of the airbag has been selected using the sets and layers option (the fold nodes are shown highlighted by yellow stars).

The local co-ordinate system is shown on the diagram.

In this example the fold point is at the default (0) position.

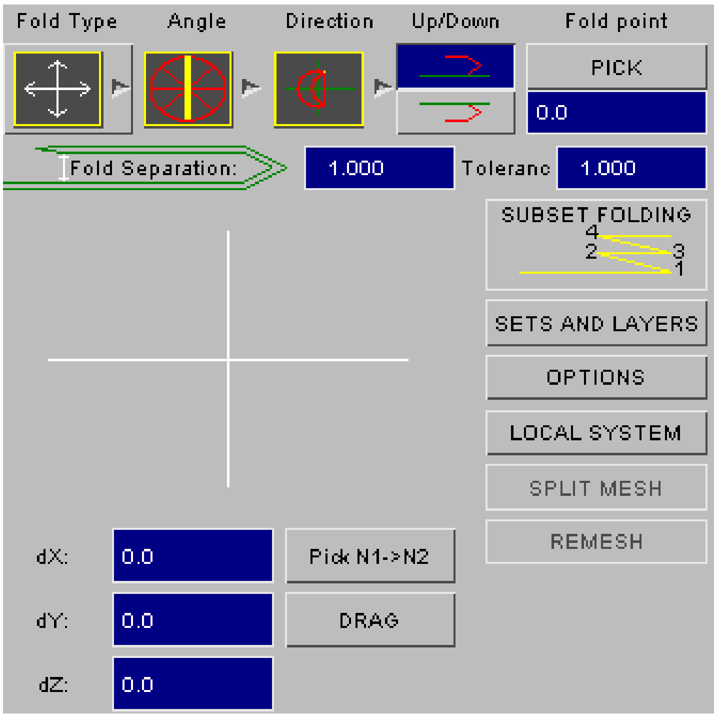


In this example the fold point has been moved to the top left of the yellow portion by **PICK**ing a new fold point.



In this example the fold coordinate system has been changed by using the **LOCAL SYSTEM** function. Note that the directions of the local axes have changed but the origin is still at 0. To change the origin a new fold position would need to be picked.

Translate Fold



Fold point: 0.0

Fold Separation: 1.000 Toleranc 1.000

dX: 0.0

dY: 0.0

dZ: 0.0

The translate fold is used for moving parts of the fold set.

The translation is done in the local co-ordinate system of the fold, NOT the global co-ordinate system.

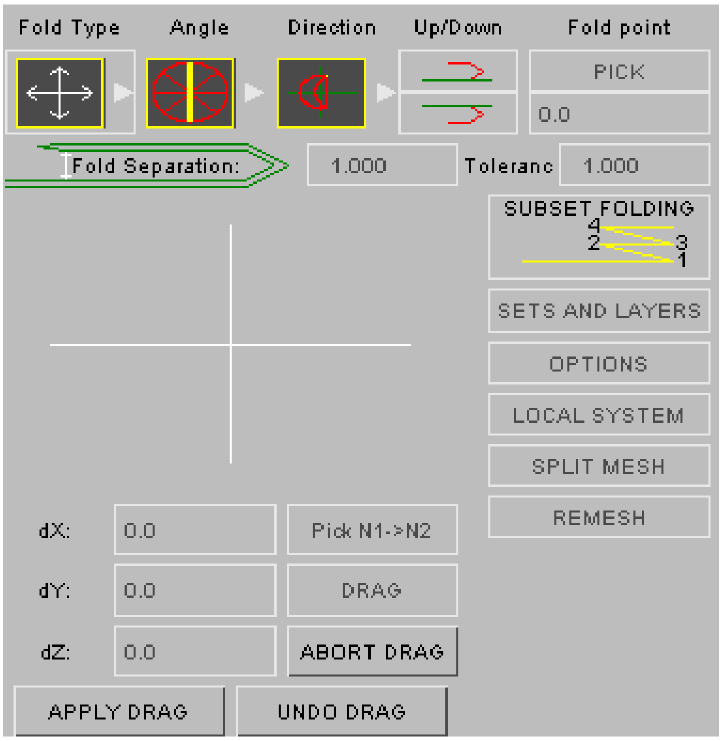
To help you visualise the local co-ordinate system the axis triad is drawn on the airbag.

The local axes can be changed using the **LOCAL SYSTEM**. The fold point (local axes origin) can be changed by selecting a new Fold point. See the examples for the scale fold as the method is identical.

The nodes/elements that you want to translate are selected in the normal way using sets and layers as required.

You can translate the airbag by one of 3 methods:

1. You can type in separate X, Y and Z distances in the text boxes.
2. You can pick 2 nodes using **Pick N1 -> N2** to define the distance.
3. You can drag the selection interactively using **DRAG**.



Fold point: 0.0

Fold Separation: 1.000 Toleranc 1.000

dX: 0.0

dY: 0.0

dZ: 0.0

Press **DRAG**. The window will change as shown on the right. All other functions are unavailable while dragging.

Click and drag with the mouse and the selection will be moved on the screen and the distance boxes updated. When the mouse button is released the screen will be redrawn. Make sure the Fold type button is toggled to show the translate fold type (not the null fold type) or you will not see the translation!

You can only drag in the XY plane of the fold. You can continue dragging the selection until you are satisfied.

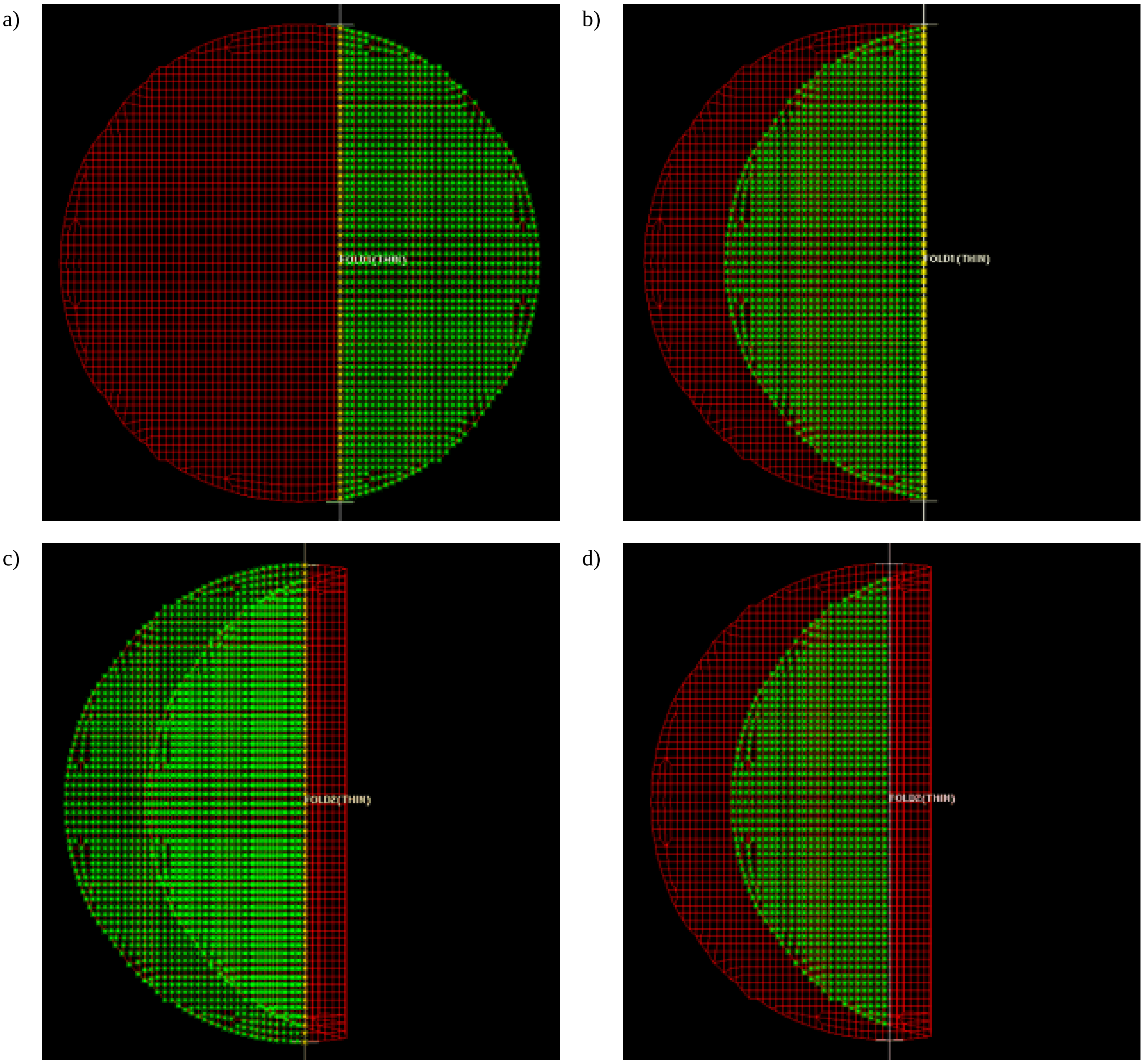
You can cancel dragging at any time by pressing **ABORT DRAG**.

You can start dragging again (undoing the last drag you made) by pressing **UNDO DRAG**.

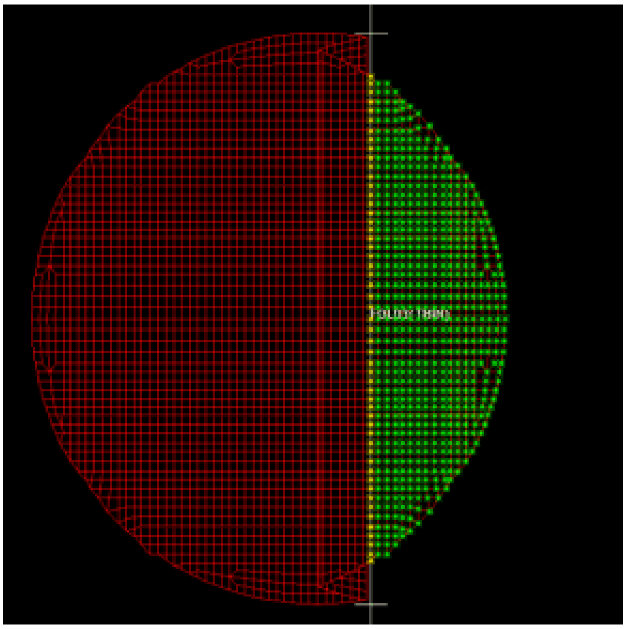
To finish the drag operation press **APPLY DRAG**. The distances will be saved.

6.1.11 Subset Folding

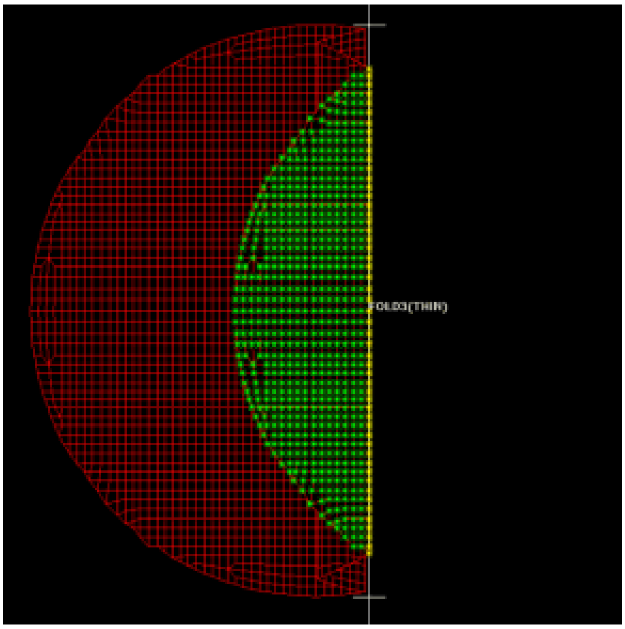
Subset folding can be used with thin, thick, version 8.0 tuck folds and align folds. It can make the process of making multiple folds considerably easier. Every time you do a fold a list of the nodes which are folded is saved. If you now want to do a new fold in which the nodes you want to fold are a subset of the previous fold (i.e. all the nodes were folded in the previous fold) instead of defining a set or layers you can just press the **SUBSET FOLDING** button and the nodes from the previous fold will be used as the input to this fold. The following figures illustrate the use of subset folding when creating thin folds.



e)



f)



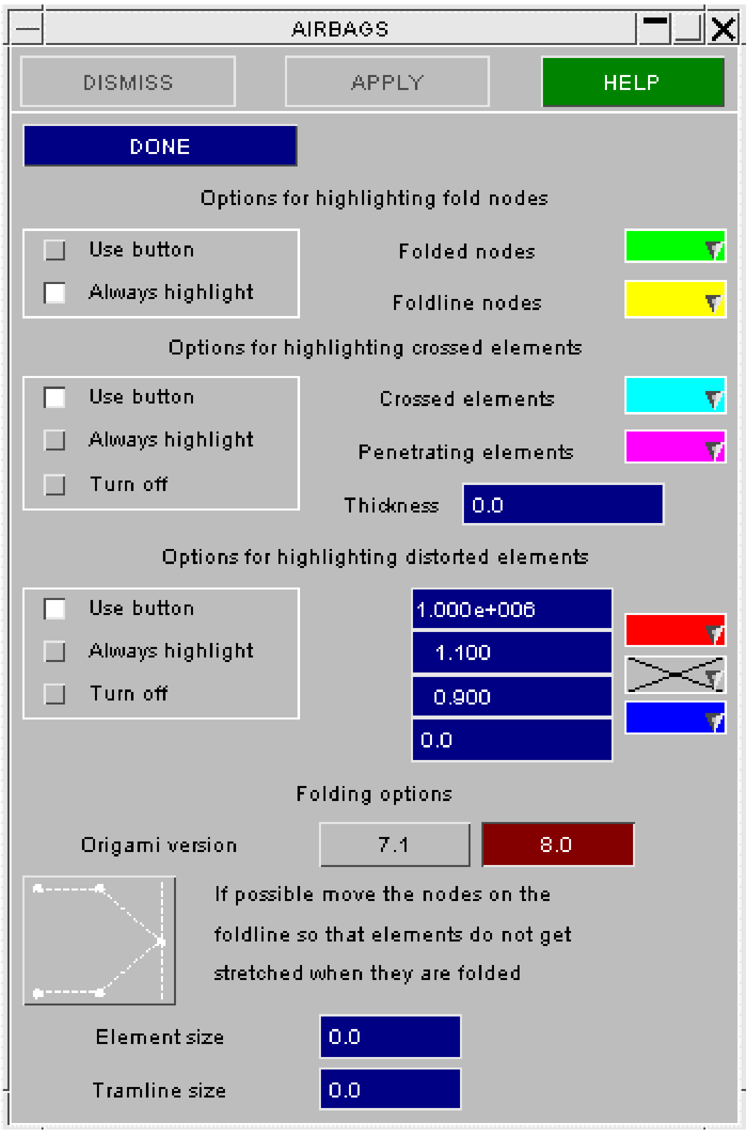
A new fold (fold 1) is created on the airbag folding from right to left. a) shows the airbag before the fold, b) shows the airbag after the fold. If a new fold (fold 2) is now created folding from left to right by default everything to the left of the fold point will be folded (c). At this point you could define a node set or use layers to select the upper layer of the airbag to fold. Instead you can press the **SUBSET FOLDING** button. Now the nodes which will be used for fold 2 are the nodes which were folded in the first fold (d). If this fold is completed and the folding process continued with subset folding then when the third fold is defined (e) the nodes are automatically selected and the fold direction swapped from forward to reverse. (f) shows the airbag after the third fold. If the folding process was continued and a fourth fold created using subset folding the fold direction would automatically swap over to be forward. This process can be used to very quickly create >zig-zag= folds on an airbag. It is much quicker as no sets or layers need to be created when doing the folds. You can turn subset folding off at any time and continue folding by the normal methods.

6.1.12 Folder Options

The **FOLDER OPTIONS** panel enables you to set various options which alter the way the folder works and what is drawn.

For fold nodes, crossed and penetrating elements and distorted elements you can individually choose to always plot them or to only plot them if the appropriate button is pressed. This option is set by using the radio buttons and setting the option **Use button** or **Always highlight**.

As the distorted and crossed element checking is very complicated it can take some time. If the delay when folding is unacceptably slow then these features can be turned off by using the **Turn off** option. If this is done then you will not be able to plot the distorted or crossed elements until one of the other options is chosen again.


AIRBAGS
DISMISS
APPLY
HELP
DONE
Options for highlighting fold nodes
□ Use button
□ Always highlight
Folded nodes
Foldline nodes
Options for highlighting crossed elements
□ Use button
□ Always highlight
□ Turn off
Crossed elements
Penetrating elements
Options for highlighting distorted elements
□ Use button
□ Always highlight
□ Turn off
Folding options
If possible move the nodes on the foldline so that elements do not get stretched when they are folded

Thickness 0.0

1.000e+006
1.100
0.900
0.0

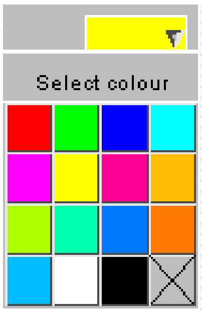
Origami version 7.1 [✓ 8.0]

Element size 0.0

Tramline size 0.0

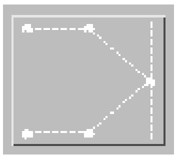
For each type of entity (e.g. Foldline nodes) you can also choose the colour that the entity is drawn in (or if it drawn at all) by using the popup menus. Each popup menu brings up a selection of colours to choose.

The colour popup allows you to choose from 15 basic colours. The cross at the bottom right of the panel (the X button) stops the entity being drawn completely. E.g. in the above figure, element distortion between 0.9 and 1.1 will not be highlighted.

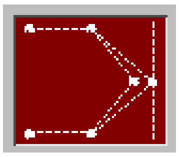


The element thickness which is used for checking penetration can be altered by typing in a new thickness in the text box. The ranges for distorted elements can similarly be changed by typing new values in the text boxes.

Version 8.0 has some new fold options such as a new tuck fold algorithm and an element stretching option. As these options could change the way an existing fold set is refolded there is an option to say if your fold set will be folded using version 7.1 techniques or version 8.0 techniques. By default any new fold set you define will be a version 8.0 fold set and you will have access to these new functions. If you read in an old fold set (version 7.1 and before) the fold set version is set to be 7.1. A warning will be output when you first select the fold set to say that you are using an old fold set. The reason a warning is given is to bring to your attention that if you change the fold set to be version 8.0 the folds may change. If you have a previously correlated airbag then leave the version at 7.1 and the folds will not be changed. You will not be able to use the new functions until the fold set is changed to be version 8.0.



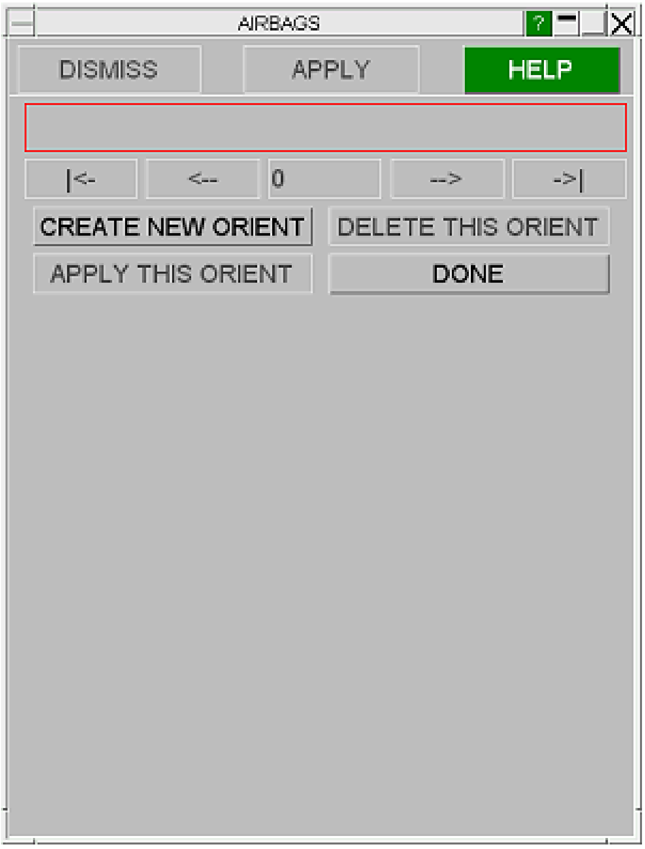
The final button on the panel is used to try to stop stretching of elements during folding. This only applies to thin folds. By default elements will be stretched as the centre plane of the elements which are being folded is placed at the fold point. Elements on one side of the plane will get smaller, elements on the other side of the plane will get larger.

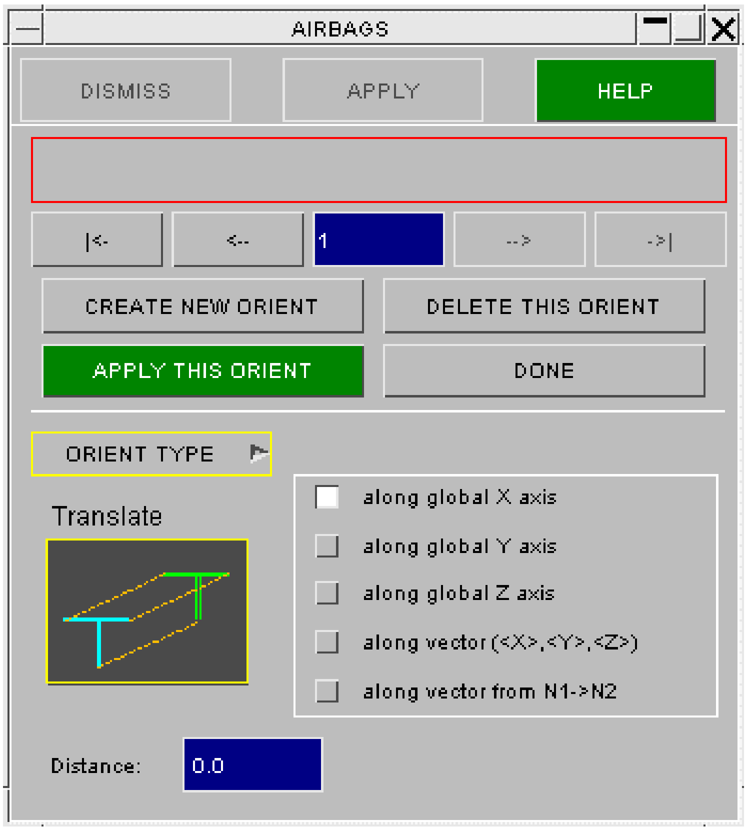


If the button is pressed then the folder will attempt to stop any elements from stretching. To do this the fold point has to be moved slightly. For folds which are less than 180º this can generally be done. If the fold is a 180º fold then if you try to fold multiple layers which are thick a point is reached when the fold cannot be done without stretching any elements. If the thickness is less than this then the stretching will be eliminated. If the thickness is more than this then the stretching will be reduced as much as possible.

6.1.13 Positioning Folded Airbags

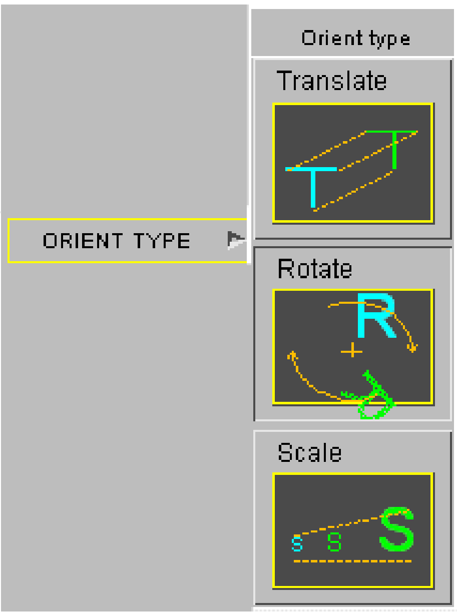
Once the airbag has been folded it can be positioned where you want it by using the **POSITION FOLDED BAG** option. The reason for using this rather than the normal **ORIENT** option in FOLDER is so that you do not lose the orientations if you refold the airbag. The orientations are created and viewed just like folds so you can create, delete or edit any orientation. They are cumulative transformations on the folded airbag. For example if you define a translation and then a rotation first the translation will be applied and then the rotation so the order of the orientations is important.





Distance: 0.0

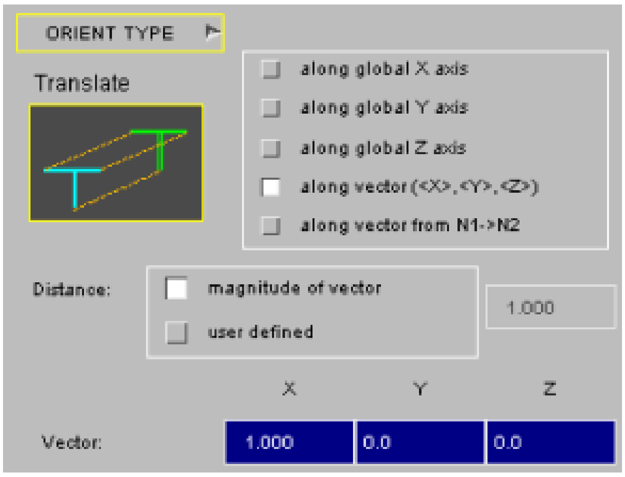
The left hand figure shows the initial window when you enter the positioning section. As there are no orientations the top row of buttons are greyed out. As orientations are defined these buttons can be used to move backwards and forwards through the orientations in exactly the same way as folds in the **SET FOLD** menu. The **DONE** button will return to the main folding window. To create a new orientation the **CREATE NEW ORIENT** button can be used. The default new orientation type is a translation (right hand figure).



At any time an orientation can be deleted by using the **DELETE THIS ORIENT** button. Once the necessary values have been given for the orientation (for example the translation distance) the orientation can be applied by using **APPLY THIS ORIENT**. Once applied the button will change to **UNDO THIS ORIENT**. This button can be used to continually toggle between the unapplied and applied view of the orientation.

Three different orientations are available; translation, rotation and scaling. To change an orientation type use the top row of buttons (**|<** , **<** , **>** , **>|**) to select the orientation number to change and then use the **ORIENT TYPE** popup menu (figure on right) and choose either **TRANSLATE**, **ROTATE** or **SCALE**. The different options for translation, rotation and scaling are described in the following sections.

Translation



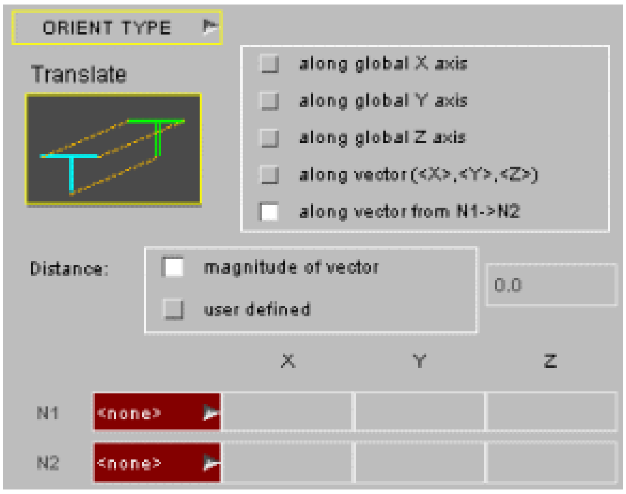
ORIENT TYPE

Translate

□ along global X axis
□ along global Y axis
□ along global Z axis
☑ along vector (<X>,<Y>,<Z>)
□ along vector from N1->N2

Distance: ☑ magnitude of vector 1.000
□ user defined

Vector: X 1.000 Y 0.0 Z 0.0



ORIENT TYPE

Translate

□ along global X axis
□ along global Y axis
□ along global Z axis
□ along vector (<X>,<Y>,<Z>)
☑ along vector from N1->N2

Distance: ☑ magnitude of vector 0.0
□ user defined

N1 <none>
N2 <none>

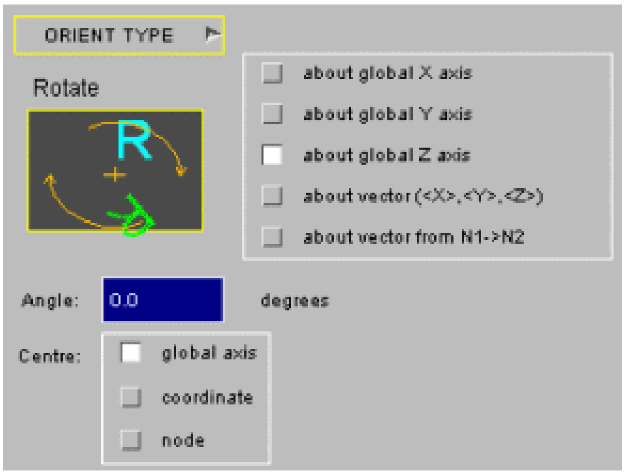
Translation along a vector <X>,<Y>,<Z> Translation along a vector from N1->N2

There are 5 different translation options. The first 3 are translating along the global X, Y or Z axis. For these options the translation distance must be given by typing the value in the text box.

The fourth option allows you to give a vector to translate along by typing in the X, Y and Z components of the vector (left hand figure). The distance that the airbag is translated along this vector can either be a user defined distance or the magnitude of the vector.

The fifth option translates the airbag along a vector defined from N1 to N2 (right hand figure). The 2 nodes can be typed in or picked using the popup menus. The translation distance can either be a user defined distance or the magnitude of the vector.

Rotation



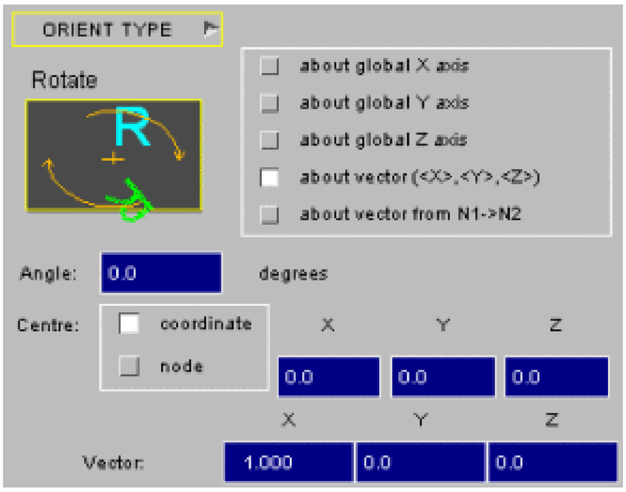
ORIENT TYPE

Rotate

□ about global X axis
□ about global Y axis
☑ about global Z axis
□ about vector (<X>,<Y>,<Z>)
□ about vector from N1->N2

Angle: 0.0 degrees

Centre: ☑ global axis
□ coordinate
□ node



ORIENT TYPE

Rotate

□ about global X axis
□ about global Y axis
□ about global Z axis
☑ about vector (<X>,<Y>,<Z>)
□ about vector from N1->N2

Angle: 0.0 degrees

Centre: ☑ coordinate X 0.0 Y 0.0 Z 0.0
□ node

Vector: X 1.000 Y 0.0 Z 0.0

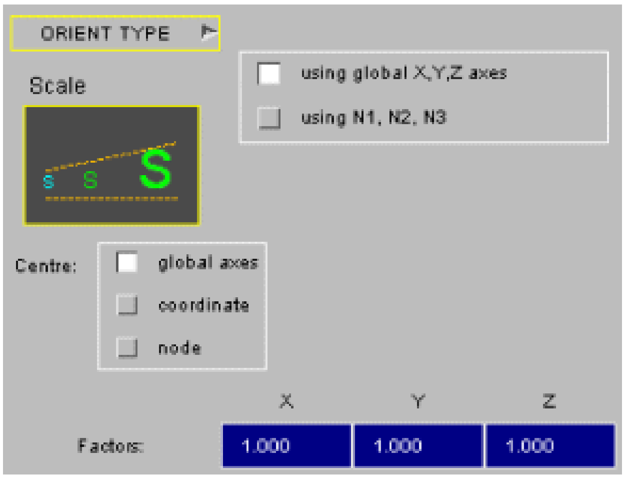
Rotation about a global axis Rotation about a vector

There are 5 different rotation options. The first 3 are rotating about the global X, Y or Z axis (left hand figure). For these options the rotation angle must be given by typing the value in the text box. There are 3 possible methods for specifying the centre of rotation. The centre can be the global axis, about a coordinate which you can type in, or about a node number which you can type in or select using the popup menu.

The fourth option allows you to give a vector to rotate about by typing in the X, Y and Z components of the vector (right hand figure). The centre of the rotation can either be a coordinate or a node.

The fifth option rotates the airbag about a vector defined from N1 to N2. The 2 nodes can be typed in or picked using the popup menus. The centre of rotation can be a coordinate, N1 on the vector or another node.

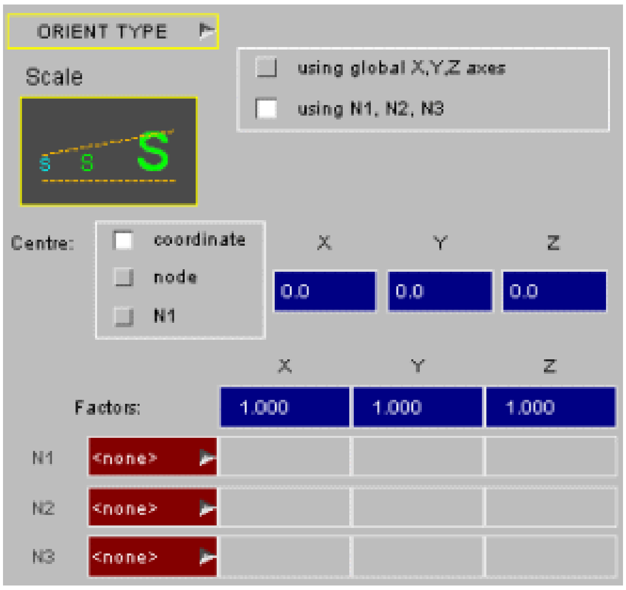
Scaling



☐ using global X,Y,Z axes
☐ using N1, N2, N3

Centre: ☐ global axes ☐ coordinate ☐ node

Factors: X 1.000 Y 1.000 Z 1.000



☐ using global X,Y,Z axes
☐ using N1, N2, N3

Centre: ☐ coordinate ☐ node ☐ N1 X 0.0 Y 0.0 Z 0.0

Factors: X 1.000 Y 1.000 Z 1.000

N1 <none>
N2 <none>
N3 <none>

Scaling using global axes

Scaling using local axes

There are 2 methods available for scaling the airbag. The first method allows you to scale the airbag in the global axes (left hand figure). Different scale factors can be used for the X, Y and Z directions if necessary. The centre for the scaling operation can be defined as either the global origin (0, 0, 0), a coordinate which you can specify by typing in the X, Y and Z values or a node number which you can pick or select by typing the number.

The second scaling method allows you to scale an airbag in directions other than the global axes by using three nodes. The three nodes are used to define a local coordinate system for the scaling. N1 is the origin for the local coordinate system. The vector from N1 to N2 is the local x axis. N3 defines another point which lies in the xy plane. The 3 nodes can be typed in or picked using the popup menus. As for the global scaling option the centre can be the origin, a coordinate or a node.

6.1.14 Saving and Reading FOLD SET/Fold Definitions

FOLD SET and FOLD definitions are written to a fold file which includes all the fold information. This is automatically written when a MADYMO input file is written. The format of these is included in the comments (see also Appendix II). When read back into FOLDER, these definitions are available to the airbag folder.

To stop any **`*FOLD SET`**, **`*FOLD`** and **`*ORIENT`** definitions from being output, the FOLD SET definitions must be deleted.

Although the **`*FOLD SET`**, **`*FOLD`** and **`*ORIENT`** definitions are available in ASCII form in this file, it is recommended that hand editing be avoided as it is error prone: to modify fold and orient definitions read them back into FOLDER.

Note also that **`*FOLD SET`** definitions should not be separated from their "parent" input decks, since they make reference to nodes, sets and coordinate systems within those decks.

6.1.15 Additional Airbag Folding Notes

The following will help users to fold airbags successfully

- For **thin** and **tuck** folds make sure that mesh lines follow fold lines exactly, (or at least within **Tolerance**). To improve accuracy of these folds it is usually important that the mesh lines adjacent to a fold line are also straight and have a constant spacing (perpendicular to the fold) from the fold mesh line. This is not so critical for other fold types. If your mesh lines do not follow the fold lines exactly this can easily be fixed by using an **ALIGN** fold.
- Be sure that the airbag does not have any cuts: it should be a closed surface. Circular holes are not a problem, but there may be computational problems if there any internal free edges.
- Thick folds and spiral folds can result in penetrations between shells on different layers. These need to be done selectively and the radius may need to be increased to avoid penetrations.
- Plan ahead if possible. Frequently, there are many different orders in which folds can be done which will result in the same final folded configuration. One order is usually much easier to accomplish than the opposite order for complex bags. If difficulty results from trying to fold a bag in one order, then perhaps try the opposite order. Subset folding can make the folding process much easier but this can only be used when the nodes for a fold are a subset of the nodes from the last fold (i.e. if the fold order in the bag is from the centre towards the edge, not from the edge towards the centre).
- Be sure always to select **NEW** before selecting options for a new fold.
- If necessary a fold can be **DELETE**d and the user can start it again if something goes wrong.
- If nothing appears to happen when creating a fold ensure that sets, carried over from the previous fold, are not defined in this definition. This can happen as much of the previous fold’s data is carried across when creating a new fold. Simply go to the **SETS AND LAYERS** feature and change the set or layer definition.

6.1.16 Folding Example

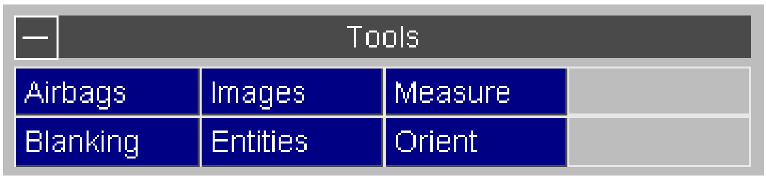
The above may sound somewhat complicated. In fact the easiest way to learn is to try the process and see what the various features do. To help this learning process the user should follow the example shown in Appendix III.

6.2 BLANKING... Setting entity visibility.

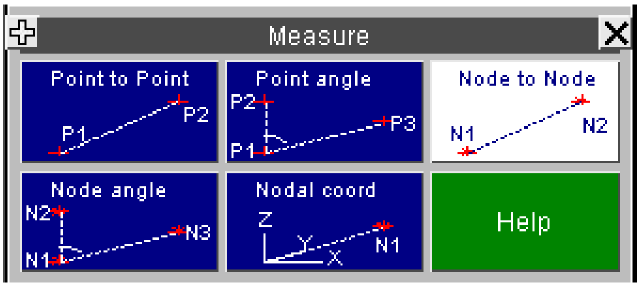
The blanking menu in the **Tools** panel is covered in a separate section of the manual - see section 4.5 for details.

6.3 MEASURE Measuring the distance and angles between nodes and points on the screen.

Section 6 index
Master index



The **MEASURE** command is invoked from the **Tools** panel at the top of the screen or from the shortcut key M. There are five options, 3 using nodes and 2 using screen points, which measure:

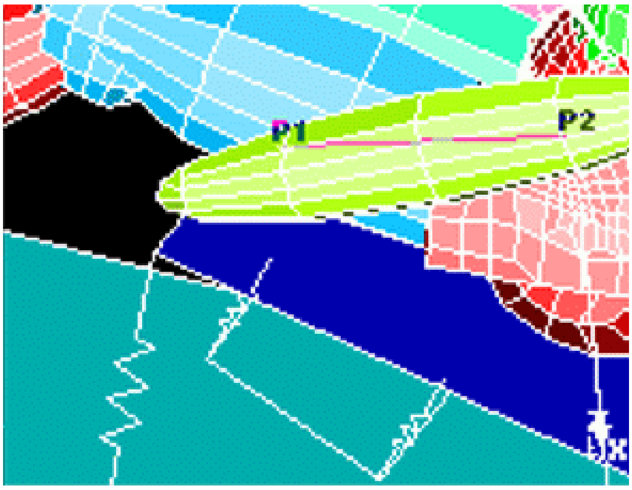


Point to Point	The (x,y) distance between two screen points P1 and P2.
Point angle	The angle between vectors P1P2 and P1P3
Node to Node	The (x,y,z) distance between two nodes N1 and N2.
Node angle	The angle between vectors N1N2 and N1N3.
Nodal coord	The coordinate of node N1.

Screen "points" are simply transient 2d locations on the display picked with the cursor. They do not have any structural significance and are not part of any airbag. Distances and angles computed from them are in the 2d screen (x,y) space system.
In this example the user has selected two points, labelled P1 and P2 on the screen, and the 2D projected vector between them is to be computed.

The reported distance, and its orientation with respect to the model, will be a function of the current transformation matrix.

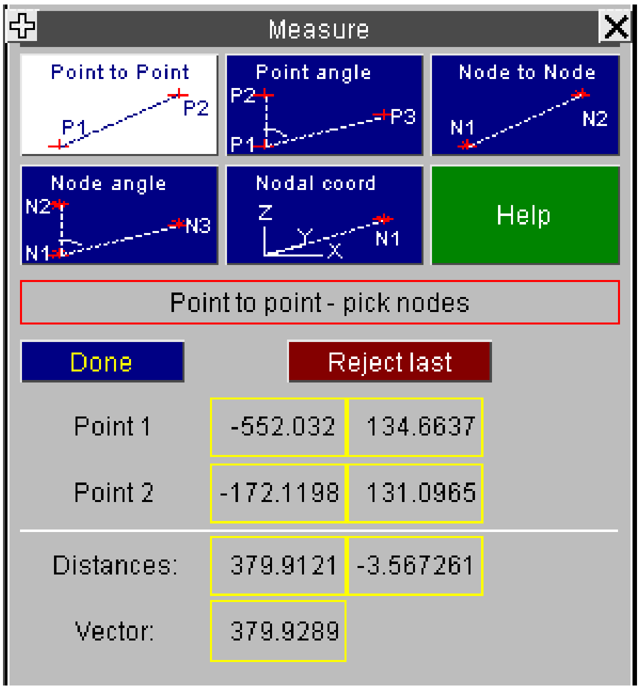
Therefore point-based measurement should be used when projected distances are required. For true 3D model space measurement it is better to use nodes.



6.3.1 Point to Point

Measures the projected 2D distance between two screen points.

Select two points with the mouse, and the vector and (x,y) components of the distance between them is reported in screen space units.



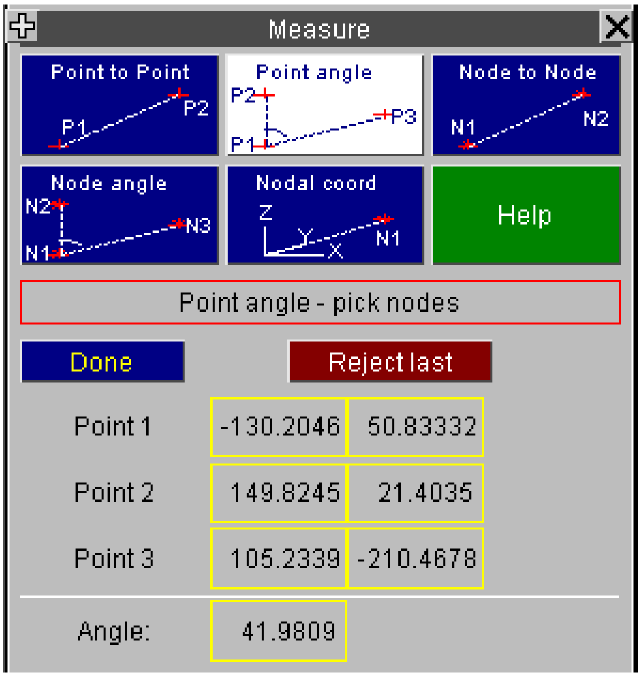
Point to point - pick nodes

Point 1	-552.032	134.6637
Point 2	-172.1198	131.0965
Distances:	379.9121	-3.567261
Vector:	379.9289	

6.3.2 Point angle

Point angle measurement computes the angle between the vectors P1P2 and P1P3.

The angle is computed in the 2D screen plane and reported in degrees.



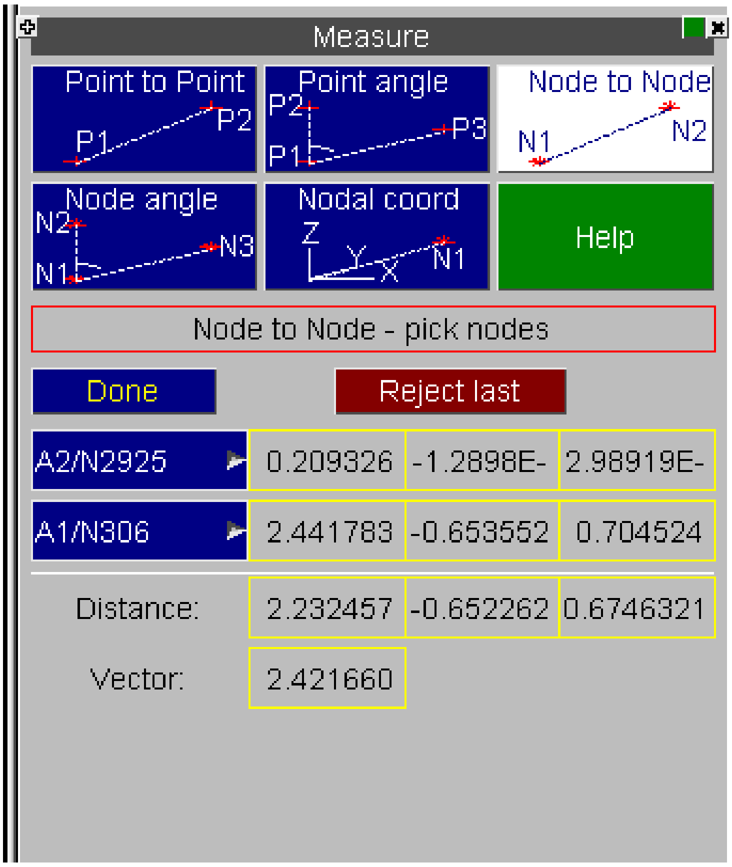
Point angle - pick nodes

Point 1	-130.2046	50.83332
Point 2	149.8245	21.4035
Point 3	105.2339	-210.4678
Angle:	41.9809	

6.3.3 Node to Node

Node to node measurement computes the vector between nodes N1 and N2, and reports it as model space (x,y,z) and magnitude components.

Nodes may either be screen-picked, or have their label typed in, or use the standard popup options. As in this example nodes need not be in the same airbag.



Node to Node - pick nodes

A2/N2925 0.209326 -1.2898E- 2.98919E-

A1/N306 2.441783 -0.653552 0.704524

Distance: 2.232457 -0.652262 0.6746321

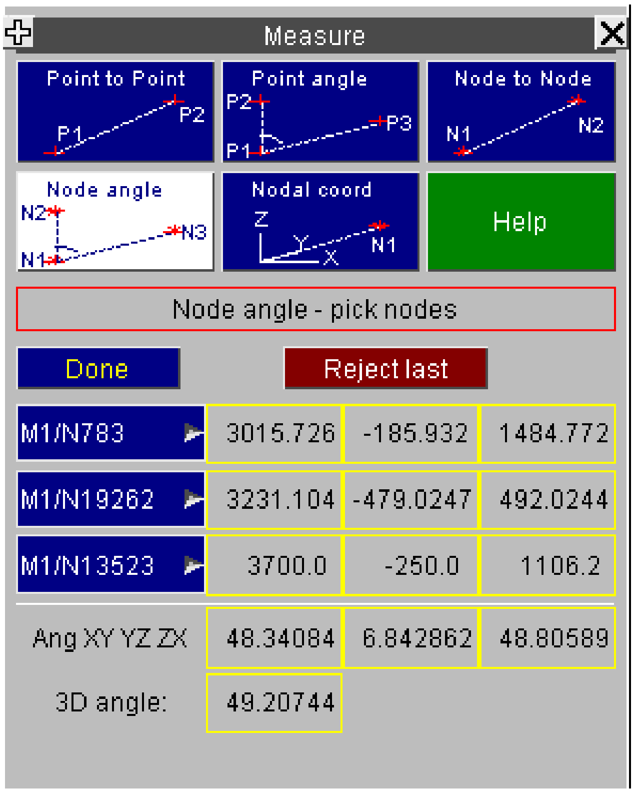
Vector: 2.421660

6.3.4 Node angle

Node angle measure computes the angle between vectors N1N2 and N1N3.

These are reported in model space (x,y), (y,z) and (z,x) planes as well as in 3D (x,y,z) space. Units are degrees.

Nodes are screen-picked or otherwise selected as in 6.5.3 above, and may be in different models.



Node angle - pick nodes

M1/N783 3015.726 -185.932 1484.772

M1/N19262 3231.104 -479.0247 492.0244

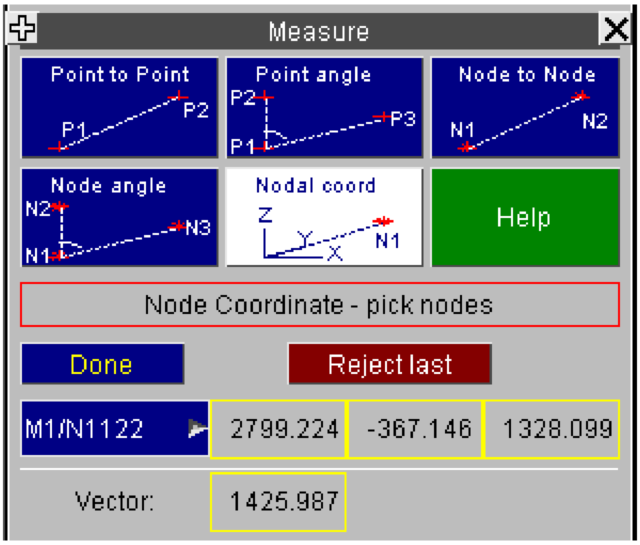
M1/N13523 3700.0 -250.0 1106.2

Ang XY YZ ZX 48.34084 6.842862 48.80589

3D angle: 49.20744

6.3.5 Nodal coord

Nodal coordinate gives the coordinates of the selected node in model space units, and also its distance from the origin.



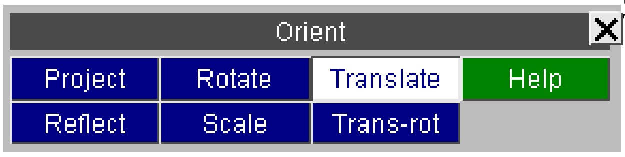
Node Coordinate - pick nodes

M1/N1122 2799.224 -367.146 1328.099

Vector: 1425.987

6.4 ORIENT: Translating, rotating, scaling and reflecting objects

Section 6 index
Master index



The **ORIENT** command is invoked from the MAIN top box, to give the master panel shown in this figure.
There are currently five types of orientation available:

TRANSLATE shift by global vector, n1->n2, or normal to plane

ROTATE rotate about global or local axes

REFLECT reflect about a distance [d] down a given axis.

SCALE factor nodal and other coordinates by [Sx,Sy,Sz]

PROJECT project nodes to line or plane

TRANS-ROT translate and rotate in one operation

Normally just the selected items are oriented by the amount specified. It is also possible to **INTERPOLATE** movement to achieve other effects.

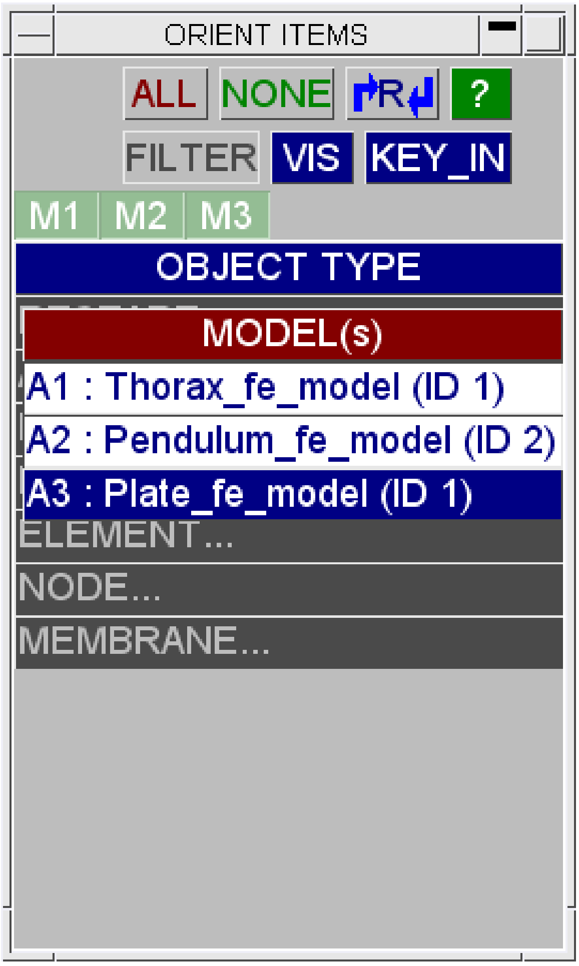
6.4.1 TRANSLATE Shifting by [dx,dy,dz]

On entering TRANSLATE you must first select the objects to be moved, then enter a global translation vector [X, Y, Z], or define a vector n1->n2 and a distance, or define a plane with 3 nodes and a distance for normal projection.

In the example in this figure the user has selected a PART via the menu, and typed in an [X,Y,Z] distance.

APPLY makes this translation actually happen.

When a transformation is applied the image is redrawn so that you can see what the result looks like, and you are given the options of accepting, rejecting or repeating the transformation before it becomes permanent.



INTERPOLATE is described in section 6.4.5 below.

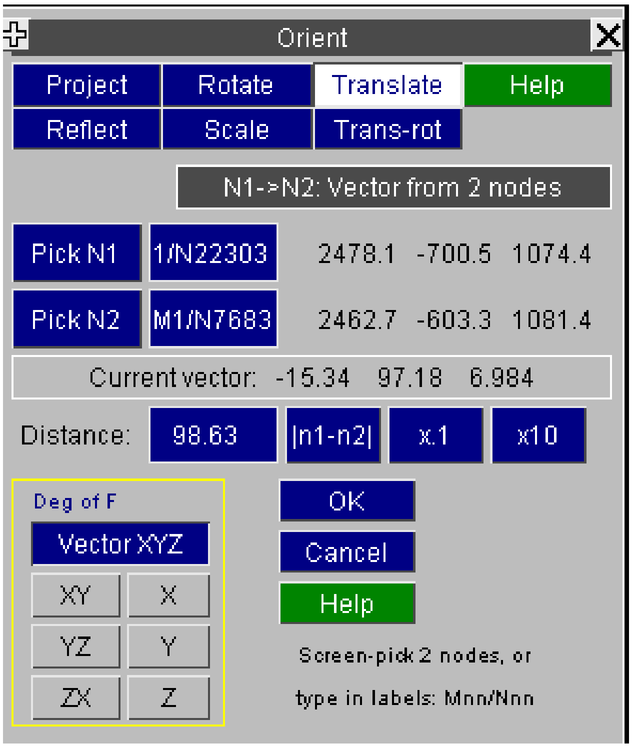
Alternative ways of defining a translation distance.

N1 -> N2 Using the vector between two nodes.

In this method you select two nodes: either by screen-picking them or by typing their labels into the relevant boxes in format A<airbag number>/N<node label>. The vector is computed from the coordinates of N2 - N1 and the distance set.

You can choose the degrees of freedom of this vector to use. By default **VECTOR_XYZ** is in force, meaning all of the [x,y,z] components, but you can reduce this to two or one component only using XY, ... Z.

When you have obtained the desired vector use OK to return to the main TRANSLATE panel, where you can then **APPLY** it.



Pick N1 1/N22303 2478.1 -700.5 1074.4

Pick N2 M1/N7683 2462.7 -603.3 1081.4

Current vector: -15.34 97.18 6.984

Distance: 98.63

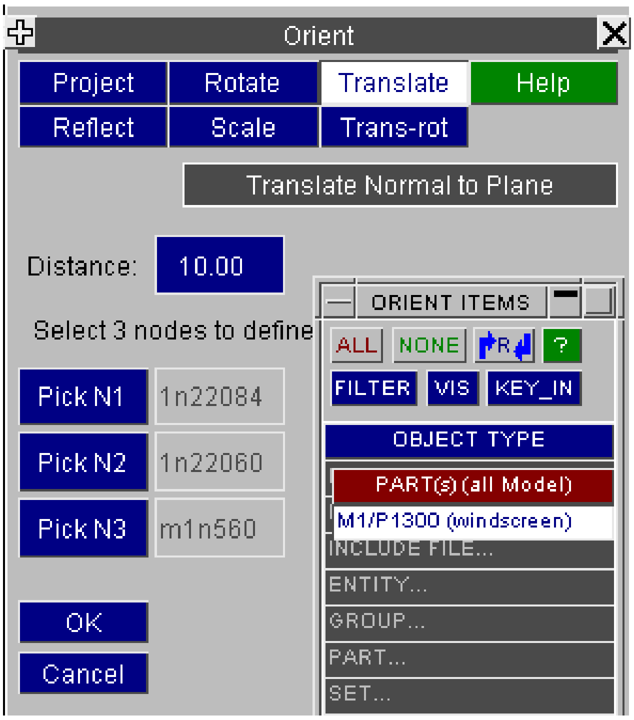
Screen-pick 2 nodes, or type in labels: Mnn/Nnn

NORMAL TO PLANE

Select the items to translate, and click on the **NORMAL_TO_PLANE** option.

Define the plane by picking on 3 nodes and set the translation distance.

Use **OK** to return to the main TRANSLATE panel, where you can then **APPLY** the orient.



Distance: 10.00

Select 3 nodes to define

Pick N1 1n22084

Pick N2 1n22060

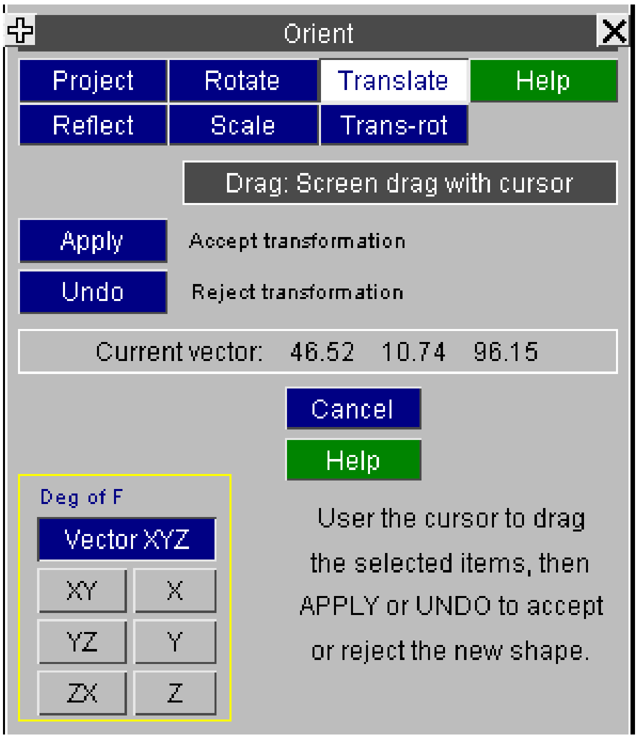
Pick N3 m1n560

DRAG Using the cursor to "drag" objects.

Click down the left mouse button at any point on the screen (it's not related to the object) and drag it in the desired direction. The object, as a reduced set of vectors if it is large, will follow the mouse across the screen, stopping when you release the mouse button.

Then use **APPLY** to accept the transformation, or **UNDO** to reject it and restore the status quo ante.

Drags take place in the plane of the screen, so the actual [x,y,z] vector will depend on the current view. It is strongly recommended that you use one of the XY ... Z options to limit object motion to either a plane or a single vector.



User the cursor to drag the selected items, then APPLY or UNDO to accept or reject the new shape.

6.4.2 ROTATE Rotating by x,y,z

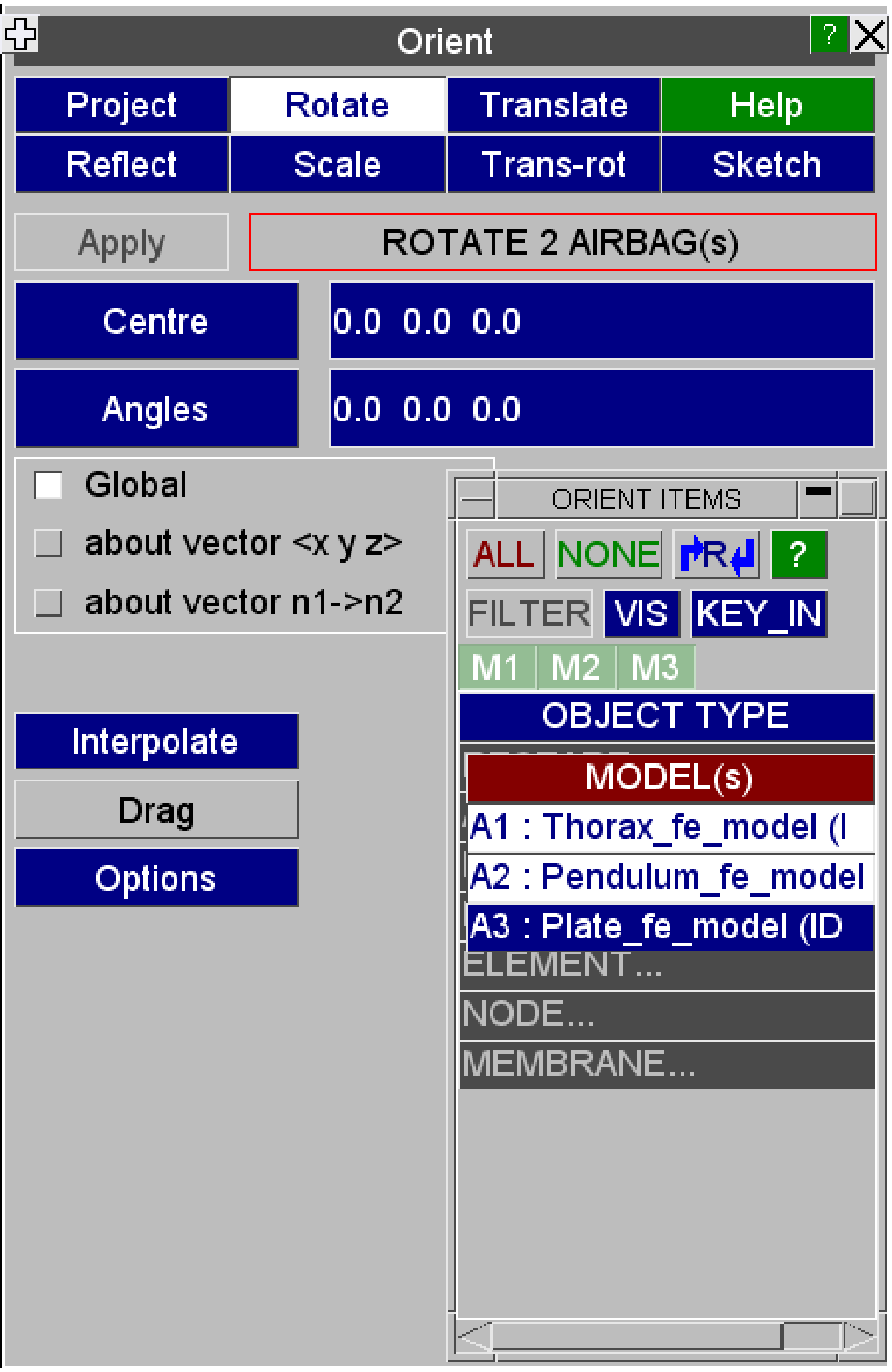
On entering ROTATE you must define:

- The objects to be rotated;
- The centre about which to rotate;
- either the rotation angles (**GLOBAL**_option) or a single angle and a local axis (**about_vector**_option)

Local axis of rotation may be defined by a vector <x y z> or two nodes.

When these have been entered press **APPLY** to make them take effect.

As with TRANSLATE when the rotation is applied the image is redrawn so that you can see what the result looks like, and you are given the options of accepting, rejecting or repeating the transformation before it becomes permanent.



CENTRE: Defining the rotation centre

Instead of typing in an [x,y,z] coordinate you can use **CENTRE** to pick a node to be used as the rotation centre. The node’s coordinate will be placed in the "centre" box for you.

ANGLES: Defining rotation angles

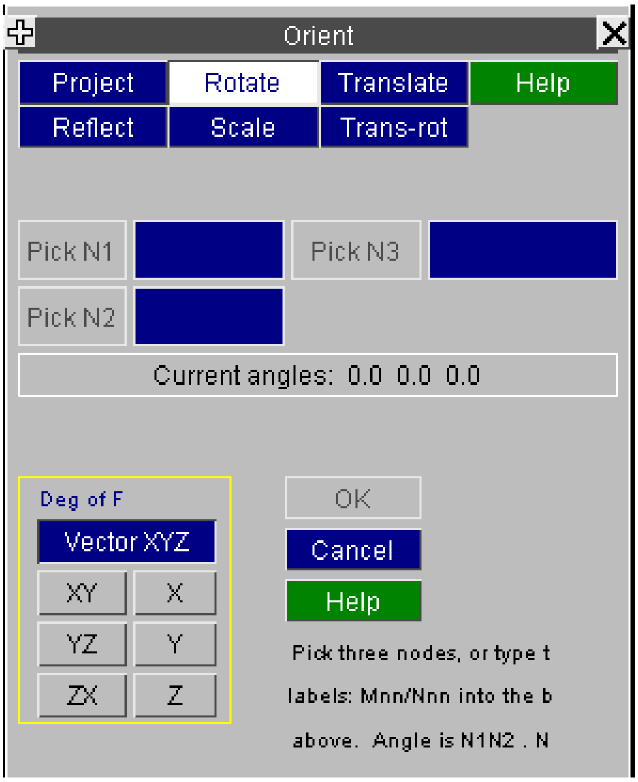
As an alternative to typing in angles about the [x,y,z] axes you can use the **ANGLES** command to calculate the angle between 3 nodes, as shown in this figure.

Pick, or type in the labels of, 3 nodes.

The vectors N1N2 and N1N3 are computed, and then the angle between them.

You can choose the 3D angle, or the projected value about any axes using **XY, ...Z** as before.

When the angle is satisfactory use **OK** to return to the main ROTATE box where you can then apply it.



Current angles: 0.0 0.0 0.0

Pick three nodes, or type t
labels: Mnn/Nnn into the b
above. Angle is N1N2 . N

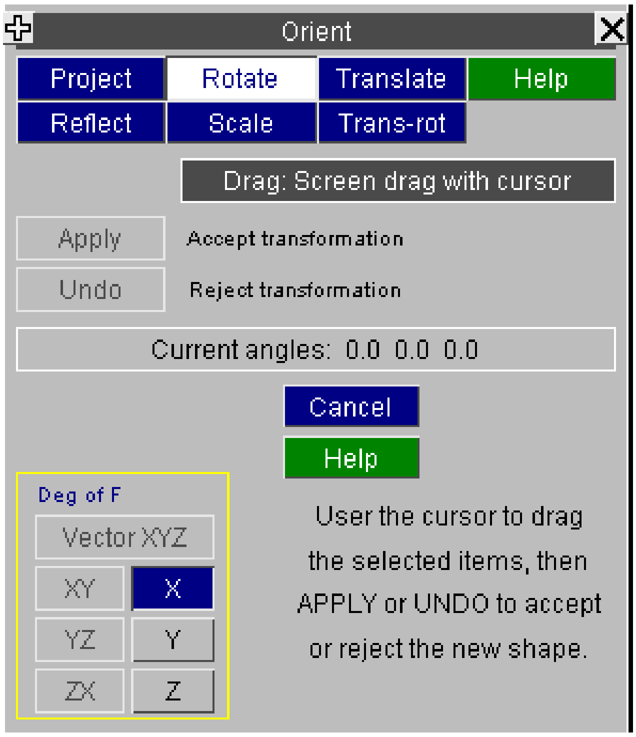
DRAG: Dragging with the cursor

As an alternative to specifying rotation angles you can "drag" the objects, about the defined centre, using the **DRAG** option shown in this figure.

Place the cursor anywhere on the graphics screen, press the left mouse button and, keeping it depressed, move it until the desired position is reached, then release it. The image (or a subset of it if it is large) will move across the screen, and then be redrawn at the new position.

Use **APPLY** to make the change permanent, or **UNDO** to reject it and return it to how it was before. (Using **CANCEL** also implicitly rejects any dragged rotations.)

Dragging can only take place about one axis at a time, the default being **X** as shown here. The reason being that dragged rotations take place about a global axis, regardless of the current view, and it becomes very difficult to see what rotations are implied by a "drag" if rotations about 2 or more axes are permitted.



Drag: Screen drag with cursor

Apply — Accept transformation

Undo — Reject transformation

Current angles: 0.0 0.0 0.0

User the cursor to drag the selected items, then APPLY or UNDO to accept or reject the new shape.

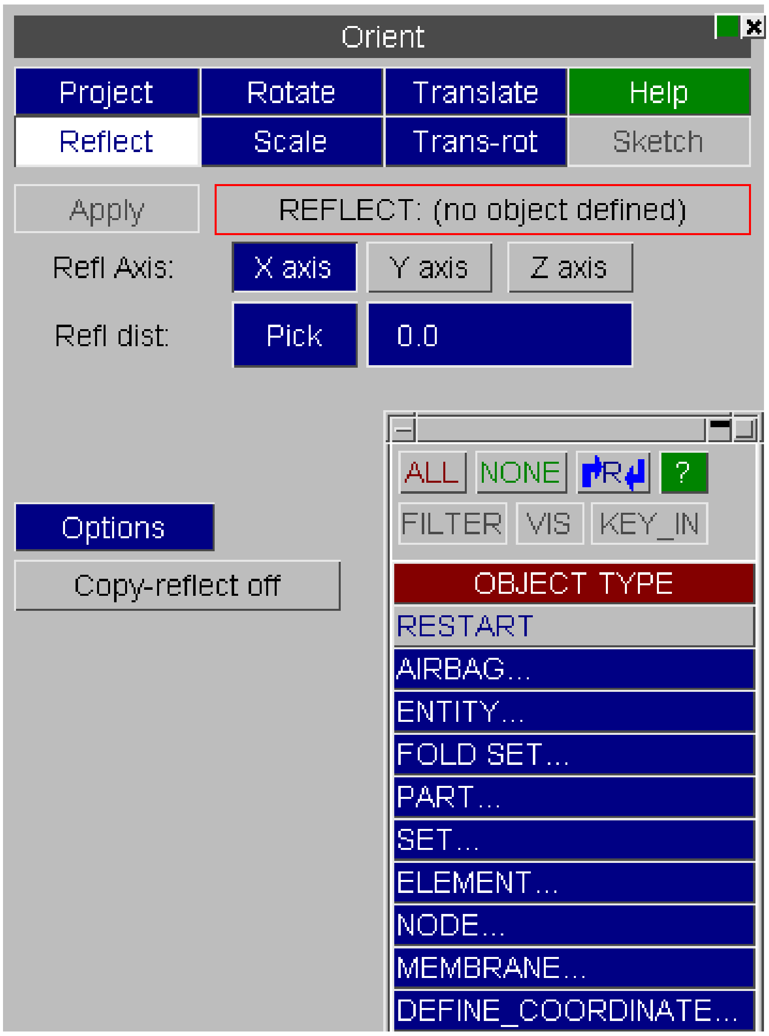
6.4.3 REFLECT: Reflect about an axis.

With **COPY-REFLECT** off.

Reflections take place about one of the global X, Y or Z axes, about a plane at a specified distance down that axis. To use it:

- Select the objects to reflect.
- Pick an axis: X axis ... Z axis;
- Define a distance, or use **PICK** to use a nodal coordinate to define the reflection plane distance.
- Use **APPLY** to make the reflection happen.

As before the image is drawn showing the new configuration, and you can accept, reject or repeat the transformation.



COPY and REFLECT

With **COPY-REFLECT ON** before the reflect function is invoked, the items to be reflected are copied.
Two options are available for treating parts:

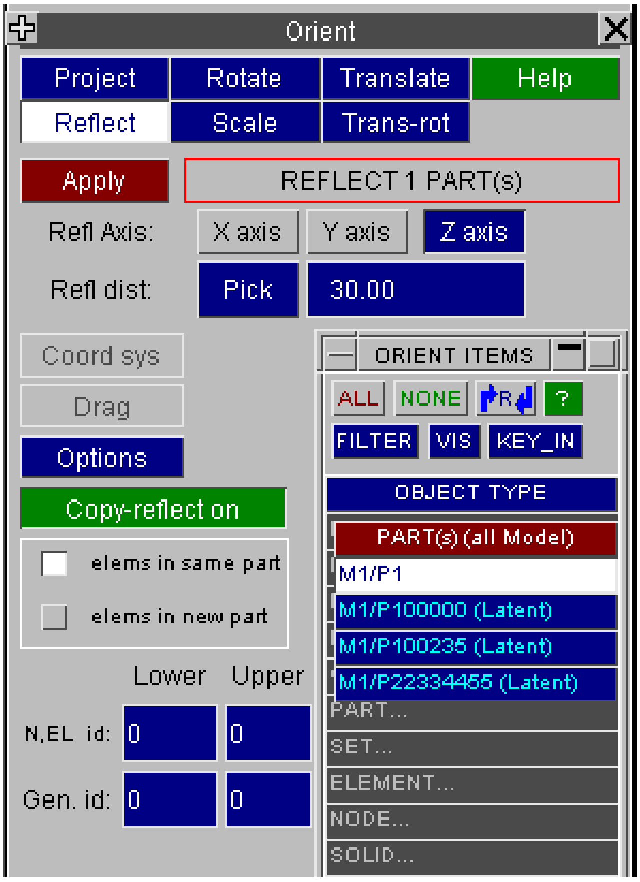
- put new elements in the original part
- create new parts for the copied elements

If the user selects the new part option items referenced by the original part (e.g. materials & contact) will also be copied.

It may require some modification to ensure that the copied part of the model is set up exactly as the user would want it.

Labels for new items: By default the new items will be labelled starting with the highest current label + 1 for each item type. If the user specifies a label range, new items will be put into free labels within this range and, only once these are exhausted, will the default apply.

Two ranges may be defined. One for the more populous type of item (nodes, elements, node sets, nrbs), the other for all other types.



Notes on REFLECT:

- At present reflection may only take place about global axes.
- ***IMPORTANT***: A reflection is ***NOT*** the same as a rotation by 180 degrees, or a scale by a negative factor!

Reflection not only moves coordinates, but also reverses the topology ordering of elements with 3 or more nodes so as to preserve their local axis systems (and +ve volume in the case of 3D elements). Whereas rotation by 180 degree, or negative scaling, just moves the coordinates. So although the results may look similar they can have different properties: use what is appropriate for your purpose.

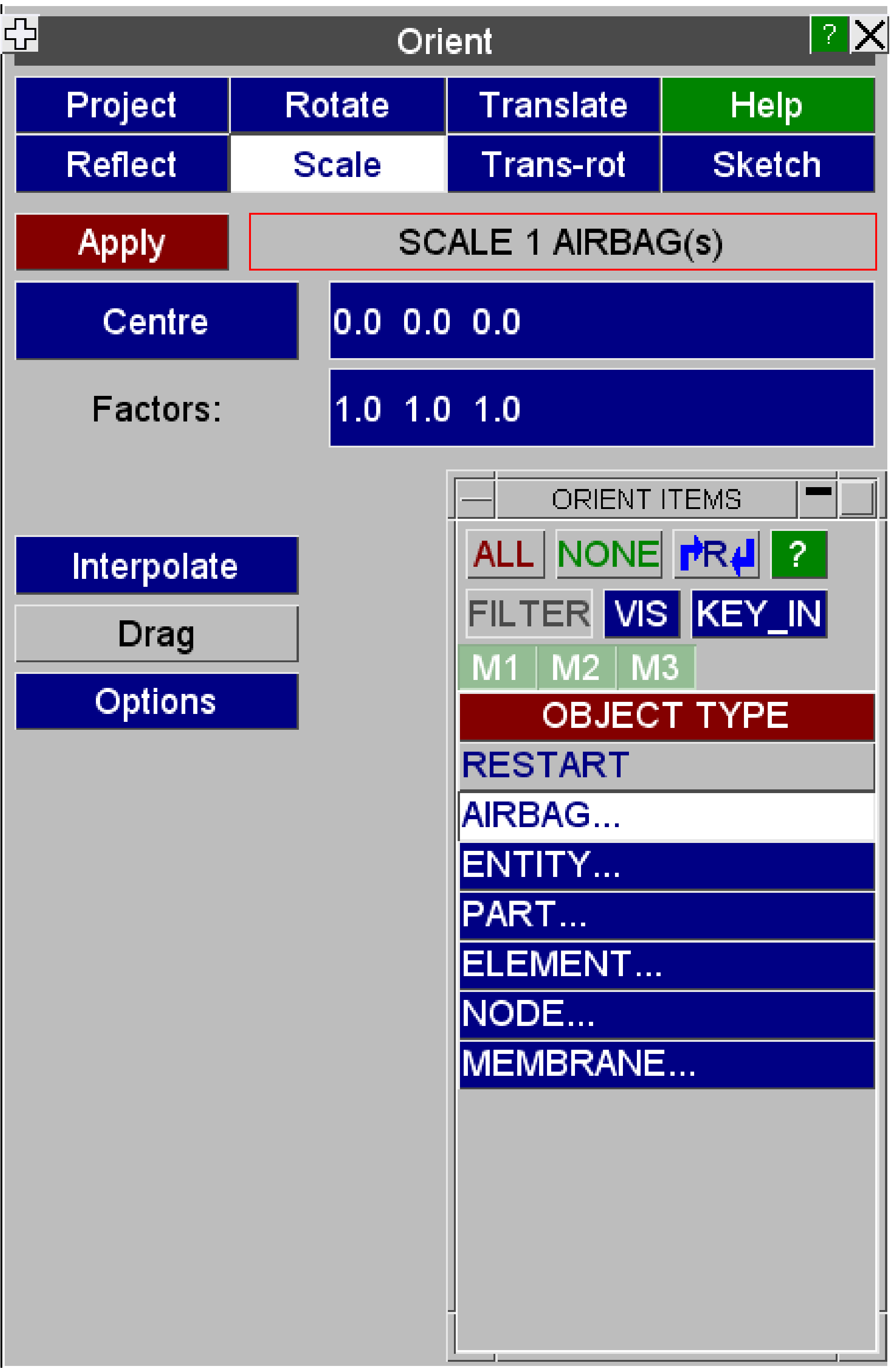
6.4.4 SCALE Scale by [Sx,Sy,Sz]

You can scale objects by independent factors about each of the [x,y,z] axes. To do this:

- Select objects as before;
- Define the coordinate to scale about.
- Define the factors for each of the [x,y,z] axes.
- Use **APPLY** to make it happen.

As before the image is drawn showing the new configuration, and you can accept, reject or repeat the transformation.

Note that negative factors are allowed, but not recommended as they reflect coordinates but not topology: see the notes above on **REFLECT**.



SCALE 1 AIRBAG(s)

Centre: 0.0 0.0 0.0

Factors: 1.0 1.0 1.0

CENTRE Defining a central coordinate to scale about.

Instead of typing in a coordinate you can use **CENTRE** to define a node whose coordinate will be used as the centre of scaling.

DRAG: Dragging with the cursor.

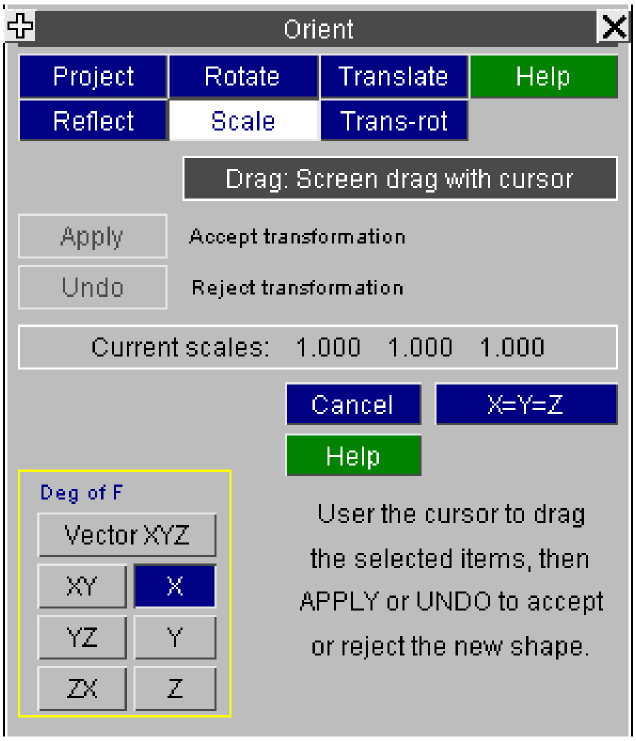
As an alternative to specifying scale factors you can "drag" the objects' scales, with respect to the defined centre, using the **DRAG** option shown in this figure.

Place the cursor anywhere on the graphics screen, press the left mouse button and, keeping it depressed, move it until the desired size is reached, then release it. The image (or a subset of it if it is large) will expand or contract on the screen, and then be redrawn at the new position.

Use **APPLY** to make the change permanent, or **UNDO** to reject it and return it to how it was before. (Using **CANCEL** also implicitly rejects any dragged rotations.)

Dragged scaling can take place using any combination of **XYZ ... Z** axis factors, and by default the factors about each axis are computed independently from the cursor movement in that axis as projected from the current view.

This tends to give unsymmetrical scaling if more than one axis is in use, so you can "clamp" all the factors to have the same values using the **X=Y=Z** button: particularly useful when combined with **VECTOR_XYZ** to expand or contract by a uniform amount in all three directions.



Current scales: 1.000 1.000 1.000

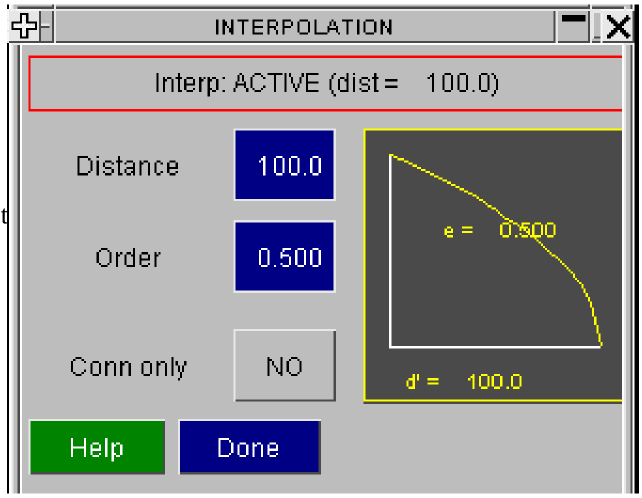
User the cursor to drag the selected items, then APPLY or UNDO to accept or reject the new shape.

6.4.5 The INTERPOLATE command.

Applying interpolation to **ORIENT** functions.

The **TRANSLATE, ROTATE** and **SCALE** functions all act by default only on the chosen items. However if **INTERPOLATE** is used the effect can be spread over a wider area by applying "interpolated" values to adjacent nodes.

This is made active by setting a **Distance** value (in this example 100) in the interpolate box. This value remains current until changed, setting this value to 0 turns interpolation off again.



Interp: ACTIVE (dist = 100.0)

Distance 100.0

Order 0.500

Conn only NO

Once a **Distance** value has been set the coordinates of unselected nodes within a radius <**Distance**> of any explicitly selected nodes will have their coordinates updated as follows:

$$C_{new} = C_{old} + \delta * \left(\frac{d}{D}\right)^{Order}$$

$$\text{Where } \left(\frac{d}{D}\right) > 0.0$$

Where: **C** = Coordinate of this node

δ = Coordinate change due to Translation / Rotation / Scale

d = Distance from this node to nearest explicitly selected node

D = The specified Distance value

Order = The specified Order value

The **Order** value defaults to 1.0, giving a linear interpolation, but any positive value > 0.001 is permissible, and a sketch of the factor vs. distance is shown in the box. (In the figure above 0.5 has been used.)

Conn only Restricting movement to "connected" nodes only.

The **Conn only** switch limits nodes that are eligible for transformation by **INTERPOLATE** still further: if it is switched on only those nodes which are connected via element mesh to explicitly chosen nodes, (as well as being within

DIstance), are eligible for movement.

"Connected" in this context means that it is possible to get from the node in question to any explicitly selected node via a continuous mesh of structural elements. The connection path does not have to be direct, FOLDER will follow mesh of any complexity, but there must not be any breaks to cross.

This is intended for use within very crowded areas of mesh where a purely geometrical selection of nodes for movement could lead to undesirable results by including unrelated items.

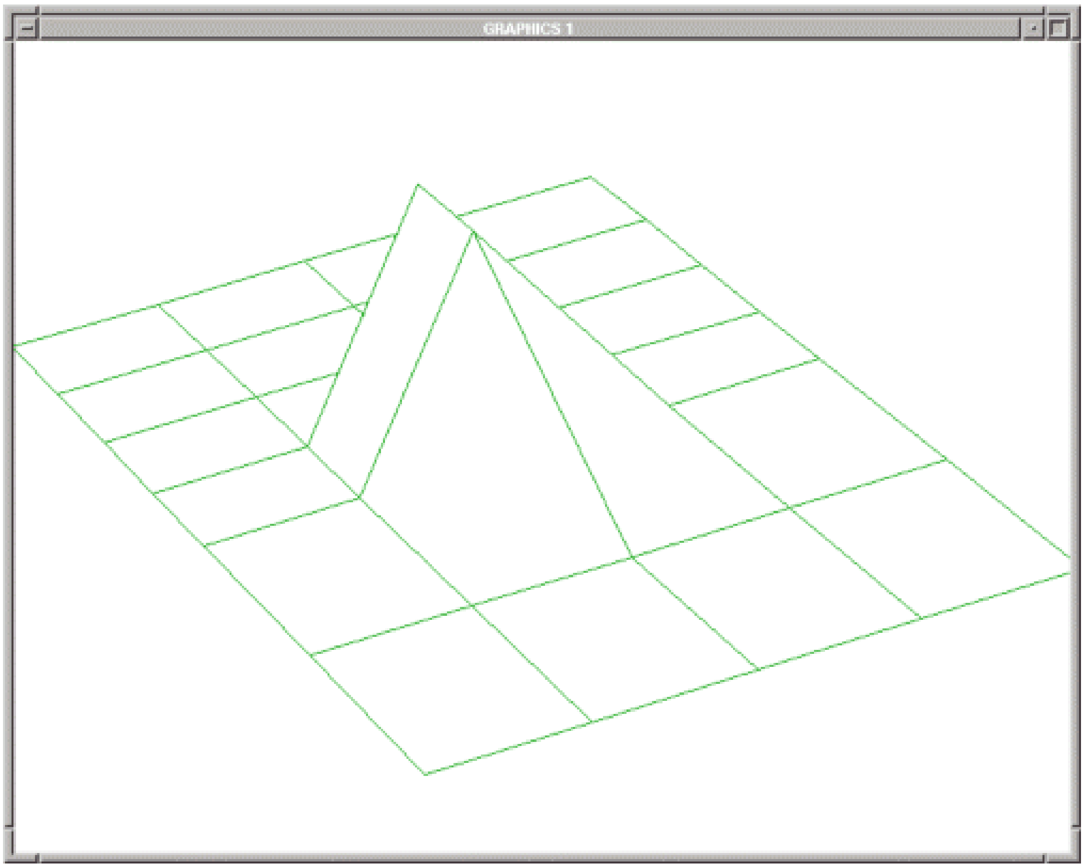
Warning about speed penalties

Using **INTERPOLATE** can slow down transformations significantly, particularly if large **Distance** values are used. This is because a bucket sort for the "nearest explicitly selected node" is required for every candidate node within **Distance** of selected nodes, and the number of nodes in the sort increases as the cube of **Distance**.

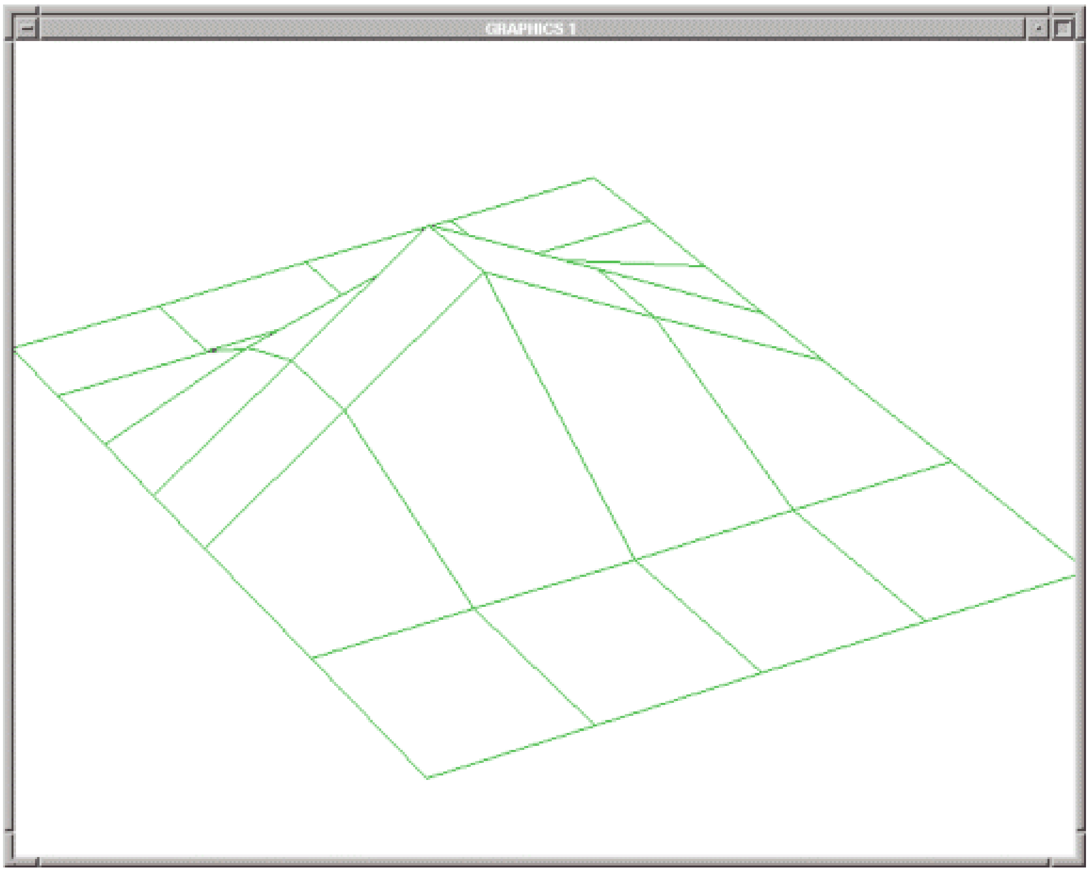
So don’t be surprised if there is a significant delay when interpolation is used with large **Distance** values in big models. Using **Conn only** can speed matters up as it usually reduces the number of candidate nodes for movement.

Example use of INTERPOLATE:

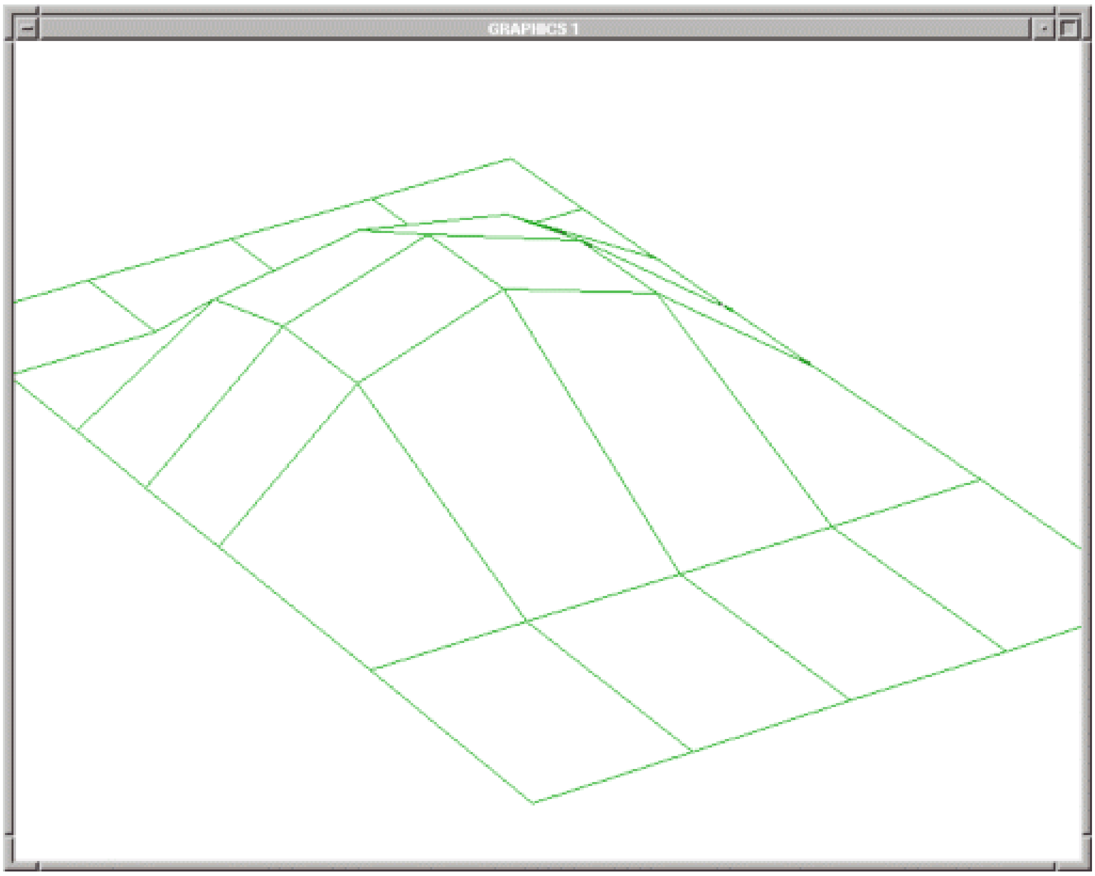
Distance = 0
In this figure two nodes in the centre of a flat plate have been raised, with no **INTERPOLATE** value set.
It is clear that only they have moved, and adjacent nodes are unaffected.



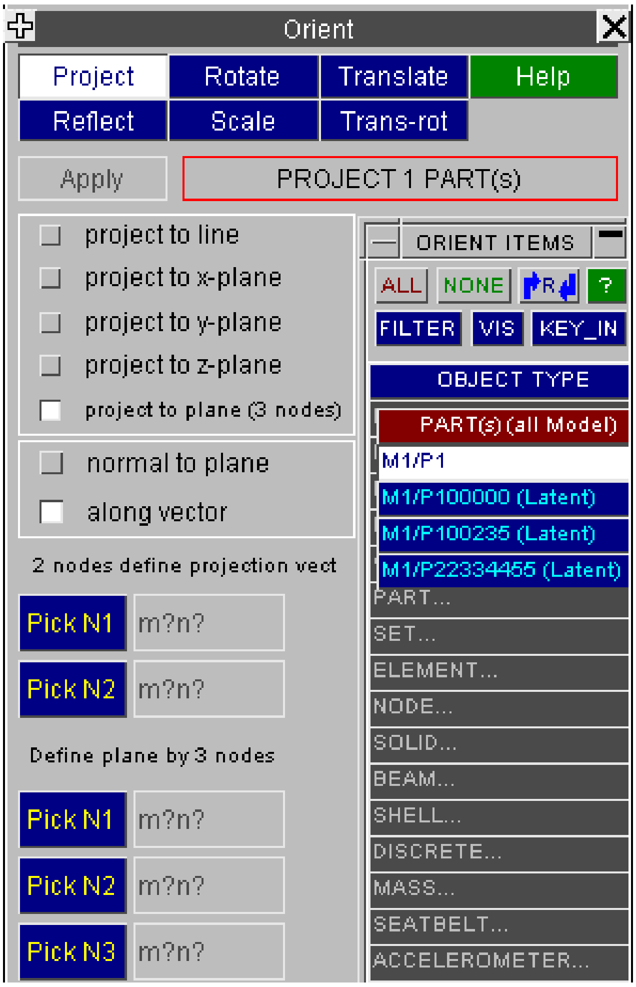
Distance = 20, **Order** = 1.0
In this figure the same nodes have been moved, but now **INTERPOLATE** has been switched on. The **Distance** chosen is equal to half the smaller mesh dimension.
Here **Order** = 1.0, so there is a linear interpolation between the selected nodes and the edge of the mesh.



Distance = 20, **Order** = 0.5
In this final figure the **Order** value has been reset to 0.5, giving a curved variation from centre to edge of the mesh. This shows how a non-linear effect can be achieved.



6.4.6. PROJECT: project to a line or plane



The projection option operates on the nodes of the items selected through the object menu.

The project-to-line operation will move them to the nearest point on the defined line.

Projection-to-plane can use either a global plane, defined by a single coordinate or a node pick, or an arbitrary plane defined by 3 nodes. Projection may be done normal to the plane or along a vector.

To apply the orient press **APPLY**.

You will then have the option to **UNDO_ALL**, if the orient is not as you wanted it.

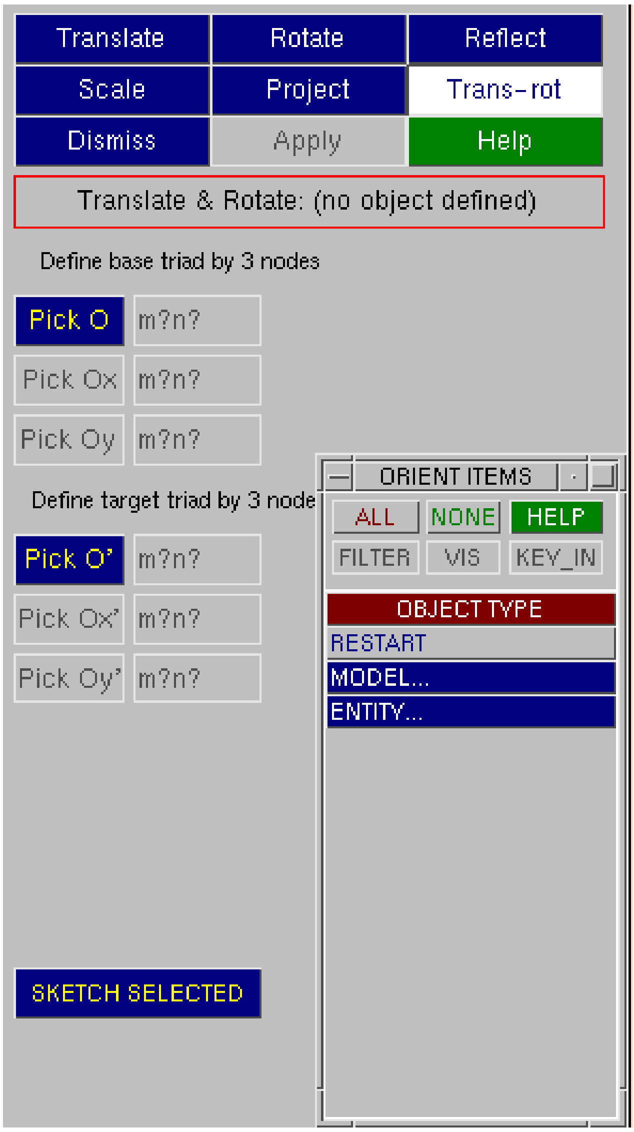
6.4.7. TRANS-ROTATE: translate and rotate

The Translate-rotate function requires the user to define a base triad and a target triad.

Each is defined by an origin node (O) a second node prescribing the X vector (Ox) and a third node lying in the XY plane (Oy). The appropriate Y and Z vectors are then found.

A translation vector of base origin node to target origin node and a set of rotations (base triad to target triad) have now been established.

This translation and rotation will then be applied to the select items.

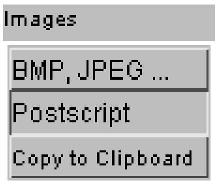


7 Images

Graphics in FOLDER can be captured and copied to file in two ways:

- By Laser plotting, generating a Postscript file, using the **POSTSCRIPT** command. Sections 8.0 to 8.4 below
- By a screen grab, generating Bitmap or JPEG files, using the **BMP,JPEG ...** command in Section 8.5 onwards

Both of these commands are found under the **IMAGES** button



Postscript laser files from FOLDER are generated in a "vector" fashion, in which the lines, polygons, text, etc which make up the image are converted to the Postscript language. A lot of control over formatting, margins and the number of plots on a page is provided, and the Postscript language itself is amenable to further editing in packages outside FOLDER. Generating a laser plot requires an explicit drawing command to generate the graphics vectors in the file.

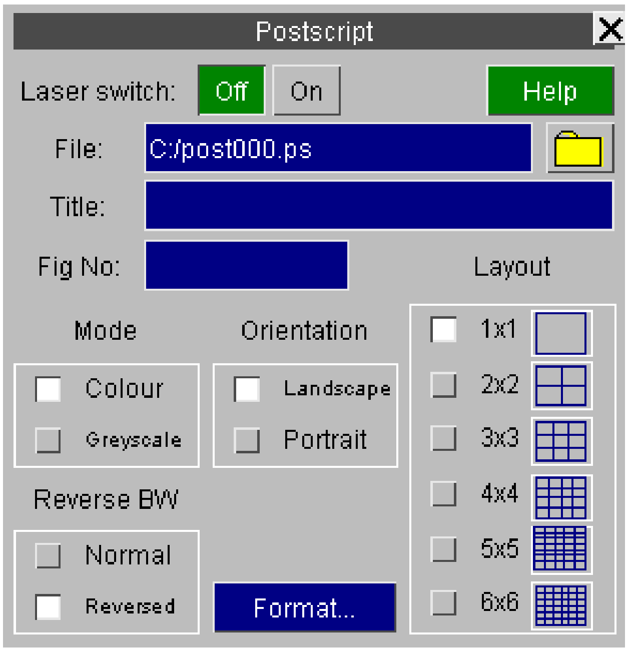
Bitmap and JPEG files are "raster" formats, captured directly from the screen image pixels. The size of these plots is determined by the graphics window resolution, and no margins or other formatting controls are provided. JPEG is the preferred format since it gives good image quality combined with small file size, however bitmap formats may be useful for packages which cannot process JPEG files. Since these files are captured from the current image no explicit drawing command needs to be issued.

7.0 **LASER**: Introduction to Laser Plotting

By default all graphics images generated by FOLDER are sent only to the screen, but you can choose to copy them to laser files.

This is done by turning the **Laser** switch **on**, following which any subsequent plots are sent both to screen and to laser files until the laser is switched **off** again.

The adjacent figure shows the basic laser plotting panel. It both controls and shows the status of the current laser file (if any).



File: C:/post000.ps

7.0.1 Laser language and file format used.

At present FOLDER only writes Postscript laser files, using PS ADOBE level 2.0 commands. These are ASCII files that can be viewed and edited using any common editor.

"Encapsulated" Postscript files are not written, but later in section 8.4 the very simple edits required to convert a file to encapsulated form are given.

Laser output is switchable between A4 (297 x 210mm), A3 (296 x 420mm) and US "letter" (11" x 8.5") paper sizes. The Postscript language makes it easy to edit files to fit other sizes.

7.0.2 Colour and Greyscale support.

Both colour and greyscale laser files may be generated. In greyscale mode FOLDER converts screen colours to shades of grey in an intelligent fashion.

7.0.3 Number and orientation of plots on a page.

The laser driver defaults to "landscape" orientation, with one plot per page. You can opt for "portrait" orientation and, in both cases, put multiple plots on a page in a variety of layouts.

7.1 LASER PLOT CONTROL

7.1.1 OFF/ON Switching laser output on/off

These commands control whether laser output is generated the next time you issue a plotting command. They have the following meanings:

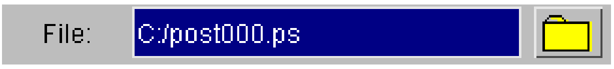
OFF No laser output is generated. (This is the default.)

ON All subsequent plots get written to laser file.

Any plot directed to laser file is sent by default to the next free sub-image (if the file has multiple plots per page), or file (if only a single image per file, or the multiple page is full).

When multiple sub-images in a file are in use the next image to be written is shown by depressing the appropriate icon in the file layout panel. You can override this and choose a different sub-image: see 7.1.5 below.

7.1.2 Choosing the laser filename


File: C:/post000.ps

When no file is currently in use the **File:** entry box will be available. You can give any valid filename for the next laser file to be written, or let FOLDER choose one for you. You can also use the button to select a file via the standard file filter box.

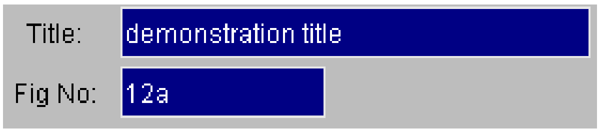
If the file already exists you will be queried to check that you genuinely want to overwrite it: you cannot append to existing laser files.

The default naming convention used by FOLDER for laser files is `postNNN.ps`, where:

`NNN` is a 3 digit number (with leading zeros if required) in the range `001` - `999`.

Any existing files are skipped when the next file in the sequence is computed.

7.1.3 Defining a label and figure number for laser plots.



Title: demonstration title

Fig No: 12a

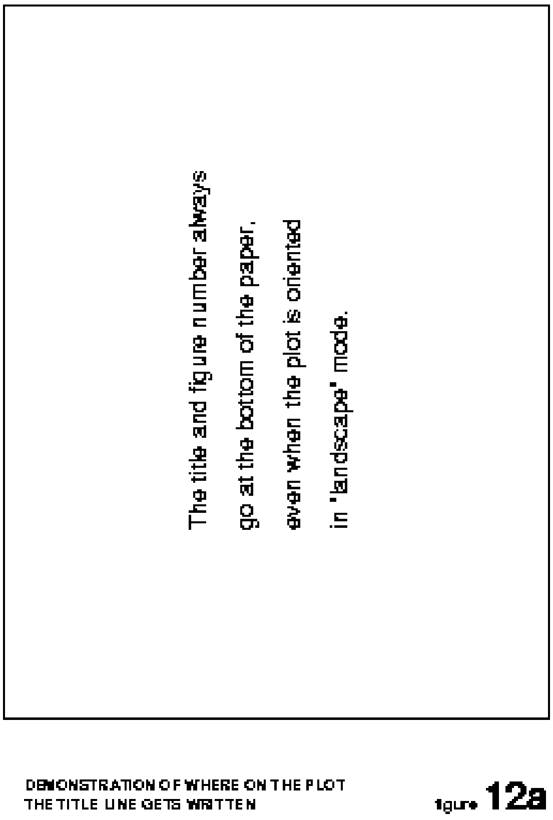
By default laser files are not labelled and have no figure number, but you may add either or both of these. They are always put at the bottom of the page, along the short edge, regardless of the orientation used for plots.

The adjacent shows the standard locations for title and figure number on laser plots.

The title may be up to 80 characters long, and is split over two lines if necessary by FOLDER.

The figure number may be any string (not just a number), and is preceded by the word "figure". It is suggested that it is 6 characters or less long: here "12a" was used.

This plot is written in "landscape" format, and reinforces the point that the title and figure number always go at the bottom of the paper, regardless of the orientation of the plot contents.

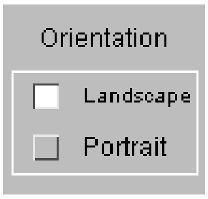


The title and figure number always
go at the bottom of the paper,
even when the plot is oriented
in "landscape" mode.

DEMONSTRATION OF WHERE ON THE PLOT
THE TITLE LINE GETS WRITTEN

figure 12a

7.1.4 Orientation



Orientation

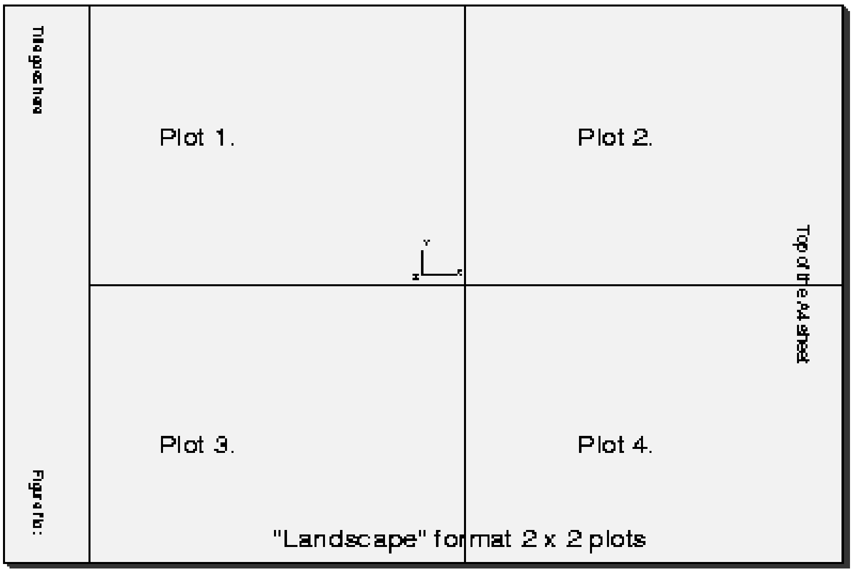
□ Landscape

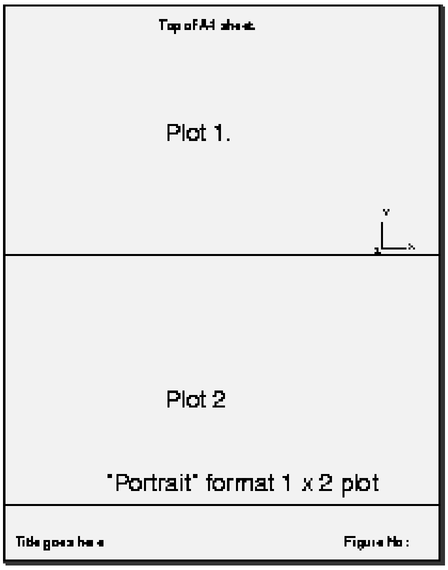
□ Portrait

Setting Landscape or Portrait plot orientation.

By default plots are in "Landscape" orientation, with the long side of the plot aligned with the long side of the paper, but you can choose "Portrait" format instead.

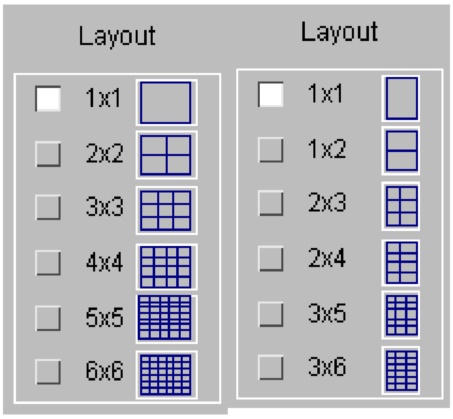
The figure below shows examples of both landscape and portrait format plots, showing how they are aligned on the paper.





This example shows examples of Landscape and Portrait plots, showing how they are oriented on the paper.

7.1.5 Layout



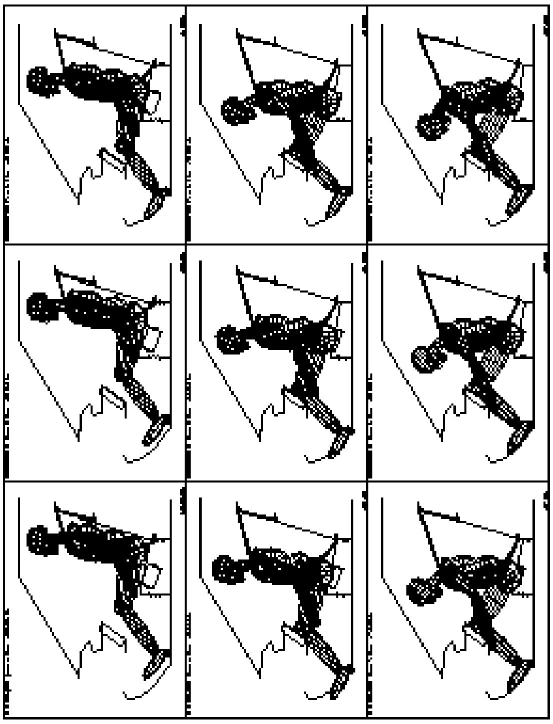
Controlling the number and layout of sub-images.

In both landscape and portrait formats it is possible to have more than one plot on a page.

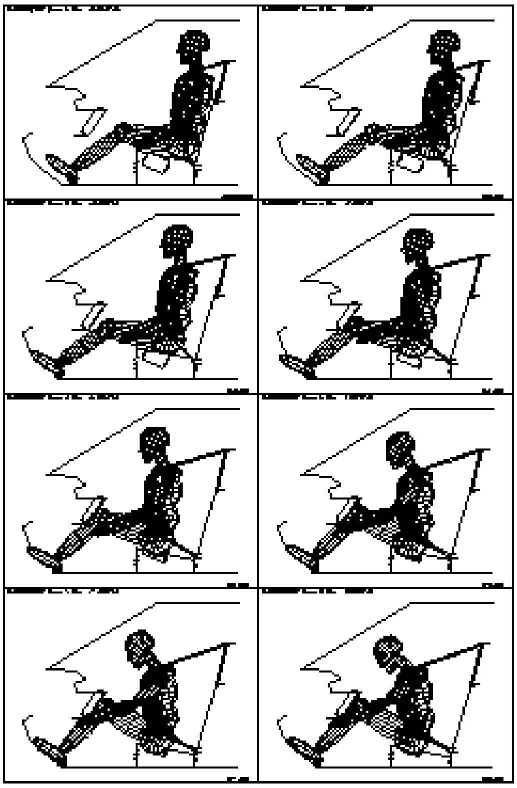
Various pre-programmed permutations of <#x> x <#y> plots are available as shown here.

Each individual plot on a page will be referred to from now as a "sub-image".

Figures(a) and (b) below show examples of 3x3 Landscape and 2x4 Portrait multiple plots.



EXAMPLE OF 3 x 3 LANDSCAPE OUTPUT figure 7.1.5a



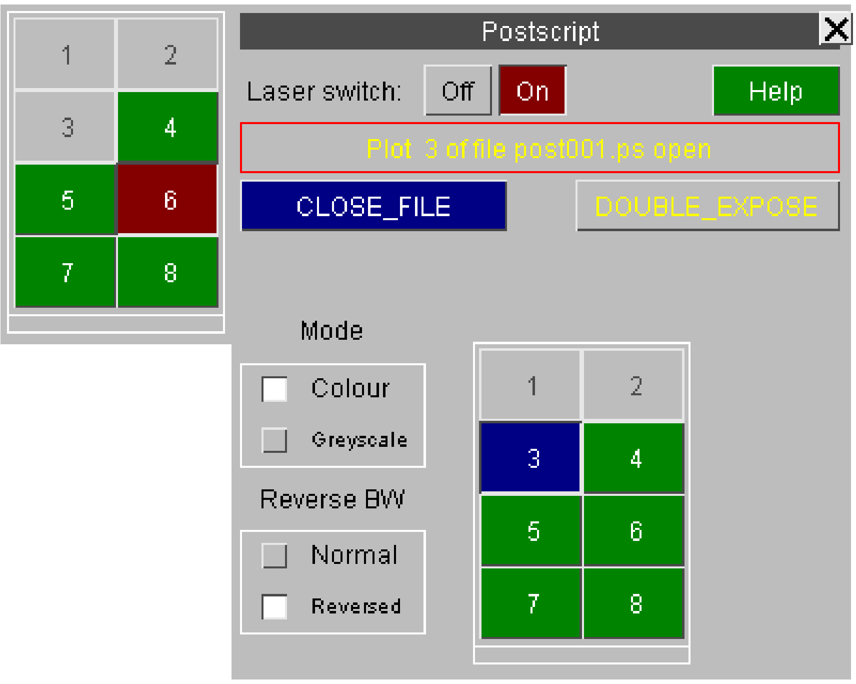
EXAMPLE OF 2 x 4 PORTRAIT OUTPUT figure 7.1.5b

Controlling the order in which multiple plots are drawn.

The right hand menu shows a typical laser panel for a 2x4 portrait plot in which sub-images 1 and 2 are complete, and sub-image 3 has received some graphics but is still "open" (see below for an explanation of this).

Normally sub-images are written in the order #1 to #n, but if the user wanted the next plot to be drawn to sub-image #6 instead of #4, he would click on the [6] icon here, giving the result shown here.

Sub-image #4 would be closed, and #6 primed to receive the next plot.



Plot 3 of file post001.ps open

The status of files, and sub-images within files.

FOLDER laser files, and sub-images within files, have one of four possible states.

Inactive	Green	No graphics written yet, and not selected for the next plot.
Selected	Red	No graphics written yet, but selected to receive the next plot.
Open	Blue	Graphics written, but file/sub-image still available to receive more information, for example from an Annotate operation.
Closed	Greyed out	File/sub-image complete, and cannot receive any more information.

The colours referred to above are used for the button icons on multiple sub-image panels, as shown in figure 7.1.5(c). Only green icons (ie those which are currently inactive) may be selected to receive the next image.

In figure 7.1.5(c) icon #3 is blue since this plot has already been written to, and is classified as "open" as shown in the message area.

How sub-image status affects the destination of graphics.

1. If no graphics have been written to a sub-image then the next plotting command will send laser output to the sub-image currently "selected". By default this will be the lowest numbered sub-image that has not yet been written to, but you can choose another as described above.
2. Once graphics have been sent to the sub-image its status changes to "open". This means that it can receive further graphics, for example from Annotate operations.
3. If a new plotting command is issued the currently "open" sub-image is closed and becomes "inactive". It can not receive any more graphics from any source, and the next free file-sub-image is "selected" for output, (see section 7.1.6 on how to send more than one picture to the same sub-image.)

Interaction between sub-images and files

A file with only a single image in it is treated in exactly the same way as an individual sub-image above, except that it is (implicitly) always "selected" for plotting until something is drawn in it.

A file with sub-images remains current (ie open) until all of the sub-images in it have been "closed", or the user closes it prematurely with a **CLOSE_FILE** command. Then FOLDER defaults to the next default filename as defined in section 7.1.2 above.

The importance of closing files.

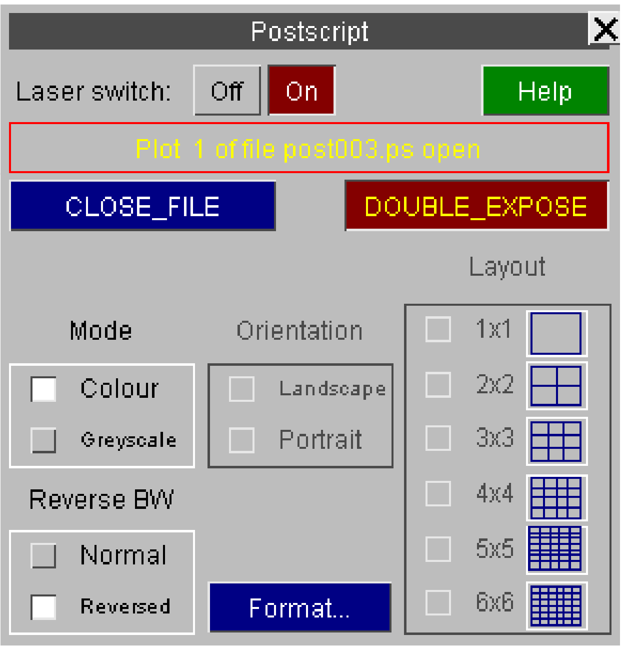
While a file is still current it is still connected to the programme, and at least some of its contents will still be held in system buffers. If you want to send it to a printer you **must** close it first using a **CLOSE_FILE** command.

This flushes any remaining data to disk and disconnects the file from the programme.

7.1.6 DOUBLE EXPOSE

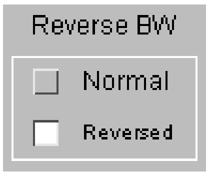
By default a sub-image is automatically closed when another plotting command is issued. By using the **DOUBLE EXPOSE** two or more screen images may be sent to the same laser plot.

Figures (a)-(e) show the use of the **DOUBLE EXPOSE** button to produce a final image composed of 3 exposures. Exposure 1 (a) and exposure 2 (b) are combined together to form (c). Exposure 3 (d) is then added to form the completed image (e).



Plot 1 of file post003.ps open

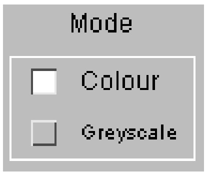
7.1.7 Reverse BW



Reversing Black and White

By default black and white are reversed in laser plots (**Reversed** mode). This means that the white lines and black background on the screen come out as black lines on a white background in laser plots.
To inhibit reversal set this switch to **Normal** mode.

7.1.8 Mode



Setting colour or greyscale output

Laser files can be created either in greyscale (default) or colour modes.

Where a file contains sub-images you can swap modes between successive images.

In greyscale mode colour images are converted to greyscale in the following ways:

Lines: All lines are reproduced in solid black, regardless of their screen colour.

Shading: Colour is ignored, and all shading is rendered in grey tones proportional to brightness. Overlay lines are drawn in black.

7.2 FORMAT...

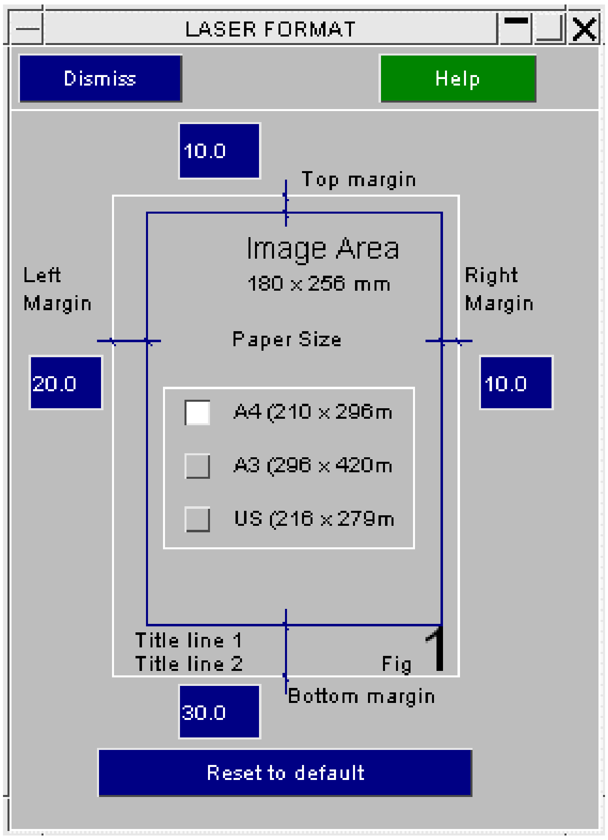
Modifying laser paper format and size on the page.

The **FORMAT** button in the laser control panel gives a special sub-menu that allows you to select:

Paper size A4, A3 or US (letter)

Margins Margins on all sides.

The margins will only apply to the axis of the plot that comes closest to the paper borders; the other axis margins will be overridden to maintain the correct aspect ratio of plots (ie no image distortion).



Top margin 10.0

Left Margin 20.0

Right Margin 10.0

Bottom margin 30.0

□ A4 (210 x 296m

□ A3 (296 x 420m

□ US (216 x 279m

7.3 Creating Encapsulated Postscript (EPS) files

EPS format is used by many software packages to import postscript images. The laser files written by FOLDER are not in EPS format, but only two very simple edits at the top of the file are required to change this.

The first seven lines of any FOLDER laser file look like

```
%!PS-Adobe-2.0
%%EndComments
%%Pages: 1
%%Page: 1 1
statusdict begin
/a1test save def
```

To convert it to EPS format you must add a "**%%BoundingBox:**" line, and delete the "**statusdict**"

```
%!PS-Adobe-2.0
%%BoundingBox: 0 0 595 842
%%EndComments
%%Pages: 1
%%Page: 1 1
/a1test save def
```

The arguments of the "BoundingBox" line are the Postscript coordinates:

<lower left> <lower right> <upper left> <upper right>

These must be expressed in raw Postscript space of 72 points per inch, and they assume that the paper is in portrait format with its origin at its lower left corner.

The values in the example above refer to A4 format: 210 x 297 mm = 595 x 842 points; US "letter" paper would give 8.5" x 11" = 612 x 792 points. Clearly a smaller bounding box would select only a subset of the image.

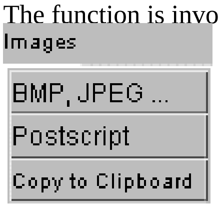
For more information on encapsulated postscript see the "PostScript Language Reference Manual, 2nd edition" by Adobe Systems Incorporated. (Published by Addison Wesley, ISBN 0-201-18127-4)

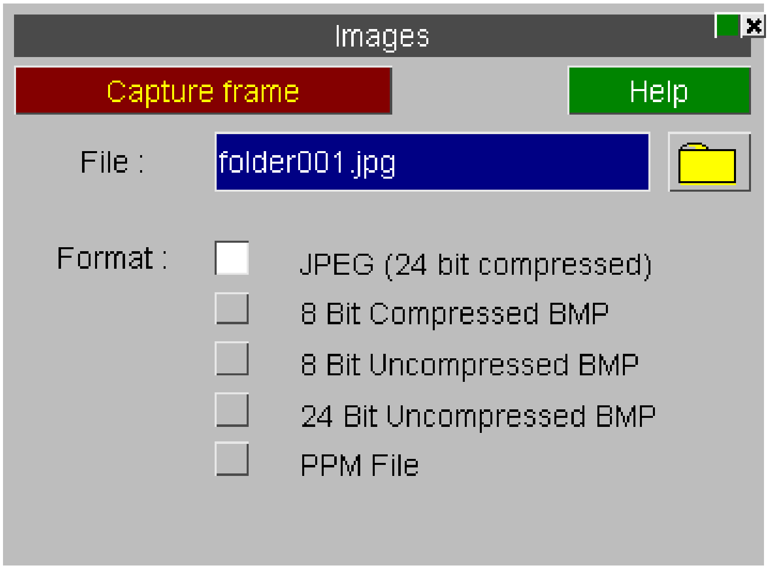
7.4 Notes on laser plotting

- Users on 3D devices should note that turning the laser on will temporarily force the graphics mode back to 2D. This is because a laser plot is intrinsically a 2D image and is computed in software.
- Transient graphics added "dynamically" to the screen are never copied to laser files. Examples are cursor-pick symbols, and also the information added interactively with the **DYNAMIC_LABEL** function.
- If an attempt to open a laser file fails because the file/directory refuses "write" permission, or the disk is full, you are warned and laser output is switched off.
- You can switch laser output off and on at will in the course of assembling a file with multiple images. Sub-images will only be written when the laser is on.

7.5 **JPEG / BITMAP**: Capturing graphics in JPEG or Bitmap formats.

The function is invoked by selecting the **BMP, JPEG** from the **Images** option in the main menu.





File : folder001.jpg

Format :
□ JPEG (24 bit compressed)
□ 8 Bit Compressed BMP
□ 8 Bit Uncompressed BMP
□ 24 Bit Uncompressed BMP
□ PPM File

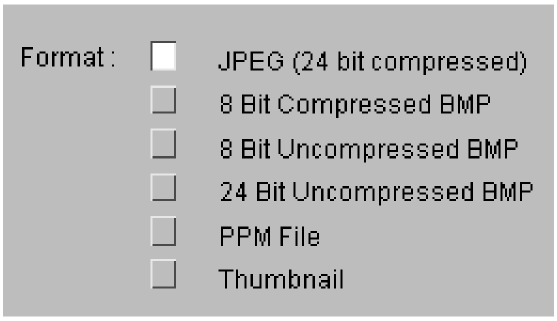
7.5.1 **CAPTURE_FRAME**: Copying the current image to file

This button "captures" the current screen image in the format chosen, copying it to the file defined. (There is no need to redraw the image as would be the case with laser plotting.)

- The X x Y resolution of the image will match exactly that of the graphics window, so make this the right size before you start.
- The depth (#bit-planes) of the image will depend upon the format chosen - see the notes on file formats below.

The image is actually regenerated to an internal buffer and captured from there, rather than the screen itself, so it doesn’t matter if the graphics window is partially or totally obscured.

7.5.2 **Format**: Choosing a suitable file format



Format :
□ JPEG (24 bit compressed)
□ 8 Bit Compressed BMP
□ 8 Bit Uncompressed BMP
□ 24 Bit Uncompressed BMP
□ PPM File
□ Thumbnail

The table below explains what the various formats are, and describes their characteristics.

File format	Extension	Description
JPEG	`.jpg`	JPEG stands for ***J***oint ***P***hotographic ***E***xperts ***G***roup. It is a compression technique based on frequency analysis of the original image which gives good compression without any appreciable loss of quality. Typically files will be < 5% of the size of the equivalent 24 bit-plane BMP format and are visually almost indistinguishable. Virtually all image processing packages can read this format, and it is the default.
Windows Bitmap (BMP) (All types)	`.bmp`	This is a very simple format that is readable in virtually any imaging package, however in its uncompressed form it is very verbose. 24 bit-plane files give excellent image quality, but are huge (#bytes = X_{res} x Y_{res} x 3). 8 bit-plane files are 1/3 of the size of their 24 bit equivalent, but the image quality suffers since only 256 colours are available. FOLDER applies dithering to increase the colour range, but this results in a loss of spatial resolution. The 8 bit-plane compressed form, which uses "run-length encoding", gives the same image quality as uncompressed 8 bit. It is still relatively verbose compared to JPEG. 8 bit-plane BMP files are larger than JPEGs and of inferior quality - use them only if you can’t use JPEG format.
Portable Pixmap (PPM)	`.ppm`	Internally this is very similar to uncompressed bitmap format. It is readable by many Unix based packages, but it offers no visual advantages over BMP files and, like them, is inferior to JPEG format.

The filename is automatically given the correct extension for its type. Although you can change these extensions it is recommended that you do not as doing so is likely to confuse Windows applications.

7.5.3 **INFO**: Further online help about formats

This gives an online "help" message explaining what the various formats are.

7.5.4 Capturing the contents of "menu" windows.

The **IMAGES** command only captures the contents of the graphics window. To copy any other window on the menu interface to a bitmap file use the **SAVE->BITMAP** option in the popup menu belonging to the **`[-]`** button at its top left corner. (See section 2.4.1).

This distinction is required because the "menu" windows are typically running in X11 window manager overlay planes, whereas the graphics window may be X11 or OpenGL, and is generally located in the screen’s image planes. Trying to capture an image which is a composite of different windows, bit-plane depths, physical location in the hardware and graphics type is possible but difficult!

7.5.5 Capturing the contents of all the FOLDER windows

If you want to grab an image of the whole FOLDER window contents: graphics, menus, the lot, then:

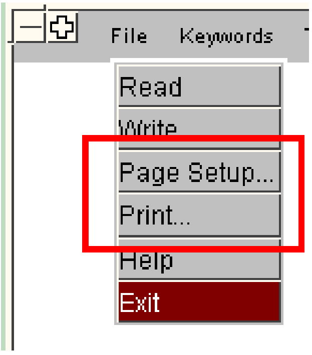
On Windows platforms:
- Use <Alt><Print Screen> with the mouse inside the FOLDER window
- This will place the image in the Windows "paste" buffer.
- It can then be pasted into other applications.

On Unix platforms:
- Use "xwd -out <filename>" and click inside the FOLDER window.
- This will create and "xwd" format file which can be used elsewhere.
- Some Unix platforms may have other, non-standard screen grabbing software.

If some windows appear to have the wrong colours this will be because the X "visuals" in the various windows are different, which is invariably the case when OpenGL graphics are used, and this has confused the screen-grabbing programme. To fix this:
- Set the **`SM_USE_VISUAL`** environment variable to "default" (eg **`setenv SM_USE_VISUAL default`**)
- Select device **XMENU...** when starting FOLDER, (see section 1.2), and choose the visual marked "default"

These two actions will force both menus and graphics to be drawn in the default visual of the window manager, which will maximise your chance of getting a sensible screen grab. However the graphics window will be using X11 (2D) rather than OpenGL (3D) graphics, and the resulting image may be inferior.

7.5.6 PRINT (Windows only)

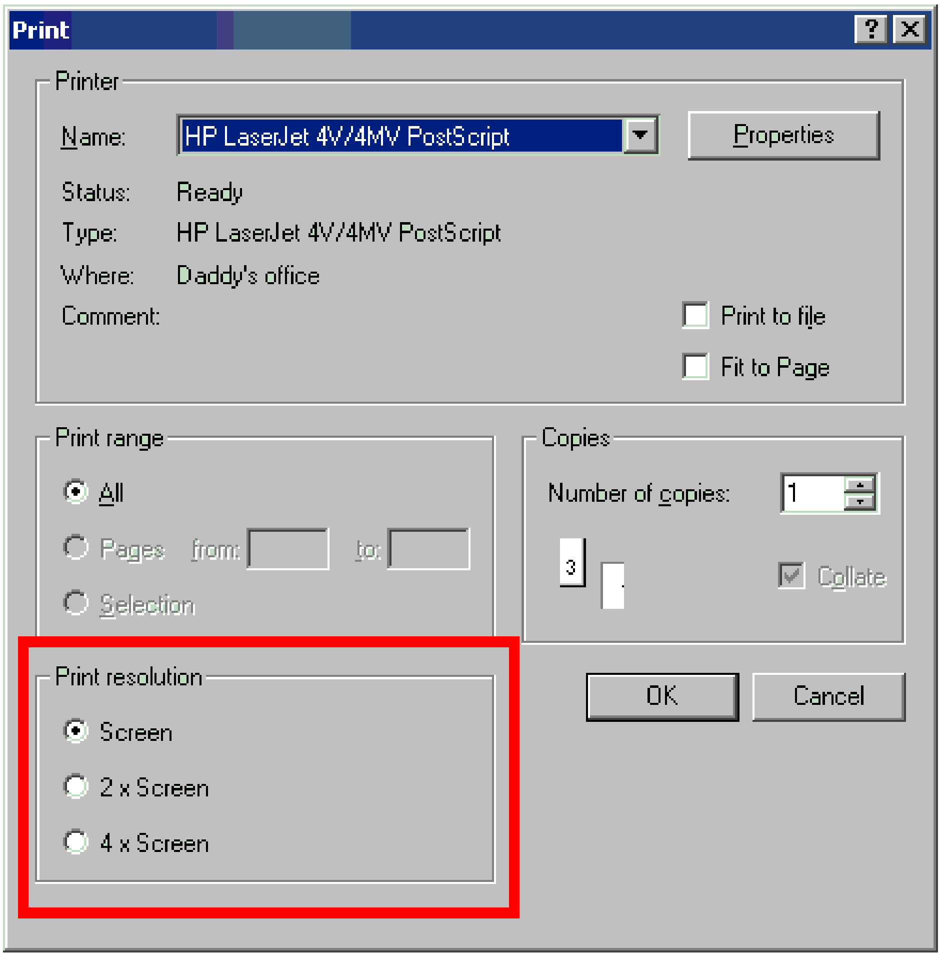


On Windows platforms only the graphics window image may be sent directly to a printer using **FILE > Print...** and **FILE > Page Setup...**

These map the standard Windows printer panels, with the addition of an optional print resolution button (see below).

(***Unix and Linux users*** will need to save a .bmp, .jpg or Postscript file and queue it externally for printing.)

Print Resolution



Print

Printer

Name: HP LaserJet 4V/4MV PostScript

Status: Ready

Type: HP LaserJet 4V/4MV PostScript

Where: Daddy's office

Comment:

□ Print to file

□ Fit to Page

Print range

● All

○ Pages from: to:

○ Selection

Copies

Number of copies: 1

☑ Collate

Print resolution

● Screen

○ 2 x Screen

○ 4 x Screen

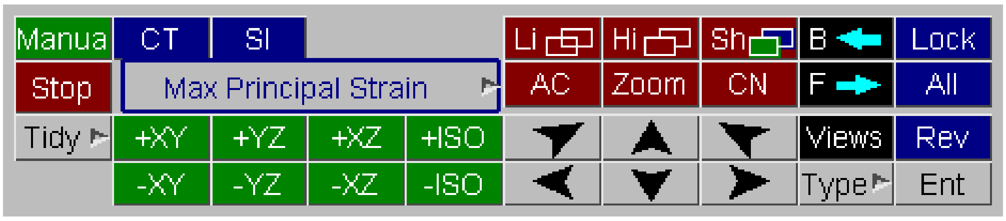
By default "Print" output will be at the screen resolution, but you can choose the options of 2x and 4x screen resolution. Higher resolution output may be preferable if printing to larger paper sizes.

Note that higher resolution files will be much larger (4x and 16x respectively) and may take correspondingly longer to processes and print.

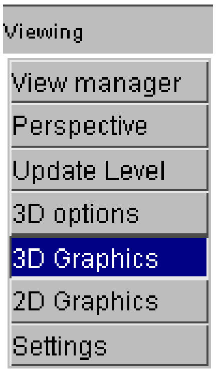
8Viewing Controls

8.0 VIEWING CONTROL

"Viewing" refers to the manipulation and presentation of images, rather than their actual generation. All basic commands live in the "Viewing and Drawing Control" box, located at the bottom right hand corner of the screen. The remaining commands can be found in the **Viewing** option in the main menu.



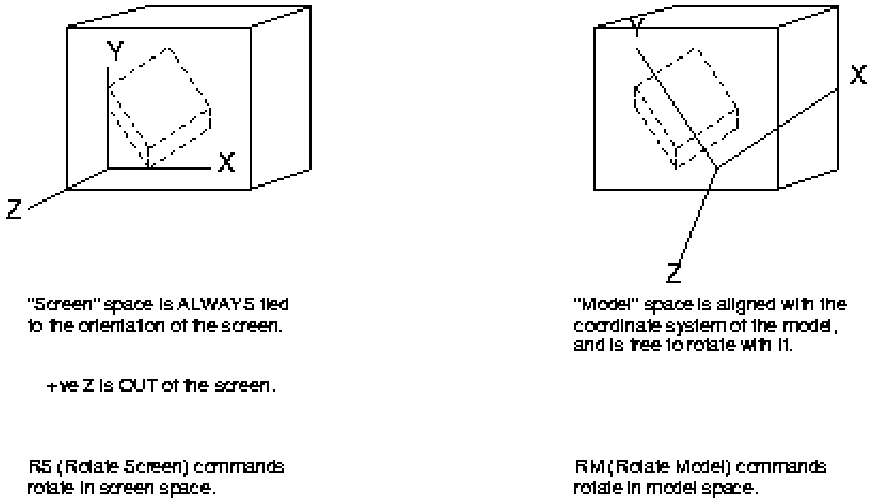
Drawing and Viewing box.



Viewing Menu

8.1 FOLDER coordinate space systems and view layout.

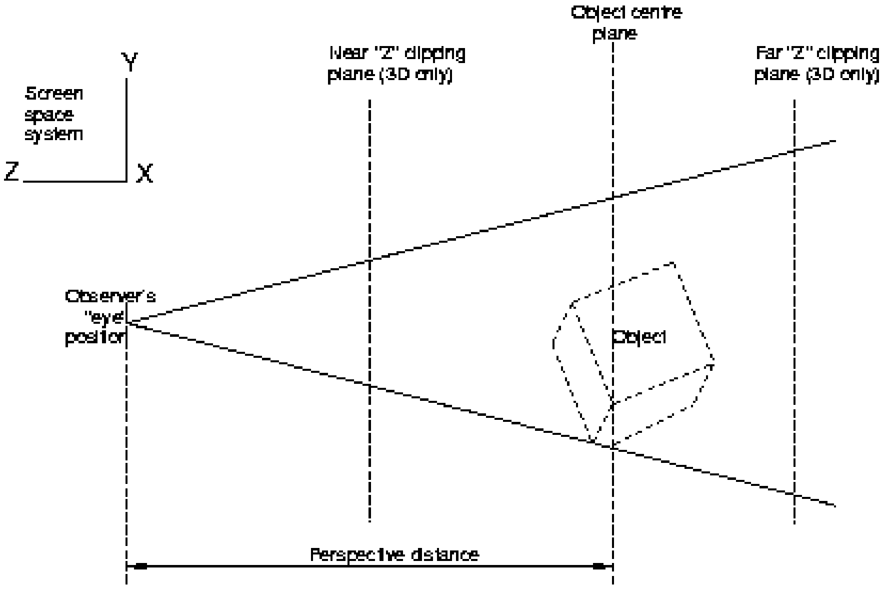
FOLDER uses two right-handed coordinate space systems for viewing: "screen" space, and "model" space. This is illustrated in figure 8.1(a):


Y
X
Z
Y
X
Z
"Screen" space is ALWAYS tied to the orientation of the screen.
+ve Z is OUT of the screen.
RS (Rotate Screen) commands rotate in screen space.
"Model" space is aligned with the coordinate system of the model, and is free to rotate with it.
RM (Rotate Model) commands rotate in model space.

Initially the two space systems are coincident, ie the initial view on the model is a plan on XY looking down the Z axis. Transformations to the current view can be applied in either space system, with the result that the model coordinate system will rotate with respect to the (fixed) screen system.

The current model orientation, (ie the axis system in the right hand side of figure 8.1(a) above), is shown by the "triad" in the bottom right of each plot.

The object exists at a point in screen space, and is seen through a viewing "frustrum" as shown in figure 8.1(b) below. The observer's (your) eye point is located at the vertex of a rectangular section frustrum, with the object some distance away in the -ve Z screen space system. The screen image is a 2D projection of what the eye sees: the sides of the frustrum clip the view to the left/right and bottom/top edges of the screen.


Object centre plane
Y
Screen space system
Near "Z" clipping plane (3D only)
Far "Z" clipping plane (3D only)
Z
X
Observer's "eye" position
Object
Perspective distance

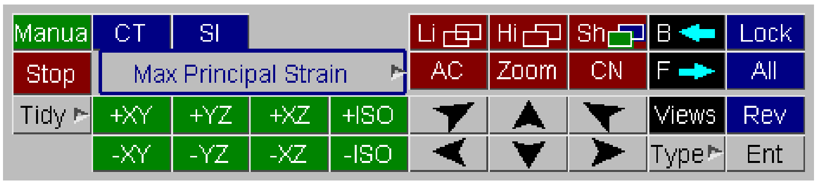
It is important to note the following:

1. Rotation of the image always takes place about the point that is the XY centre of the screen (in screen space coordinates), at the "object centre plane" (which gives the screen Z location). Thus in the example above roughly at the "O" of "Object".
2. The example above implies a perspective projection. In fact FOLDER defaults to a parallel (orthographic) projection, in which the sides of the frustrum are parallel and perspective is irrelevant. Nevertheless the object

centre plane is still significant, since this still gives the screen Z coordinate about which rotations take place. You can turn perspective on/off and alter its distance at will.

3. You can change the scale ("zoom" in/out) of your image. This effectively changes the angle of view of the frustrum above: zooming in makes it narrower, zooming out wider. But note that this does not change your distance from the object: changing the scale is like putting a lens of a different focal length on your camera, to change your distance from the object you must alter the perspective distance.
4. The near and far "Z" clipping planes shown here only apply on 3D hardware that is capable of this. See section 8.6.

8.2 The Viewing Control box

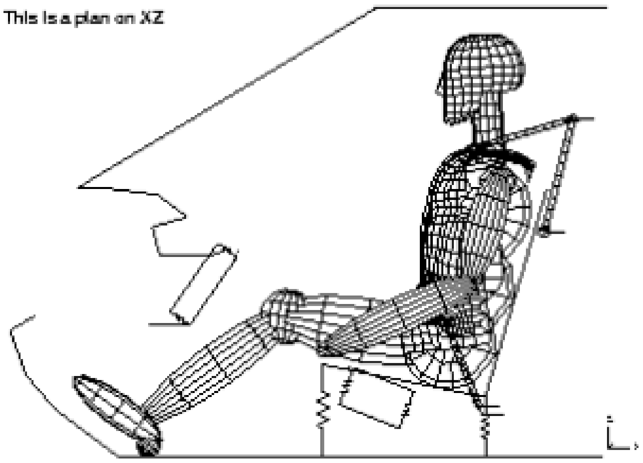


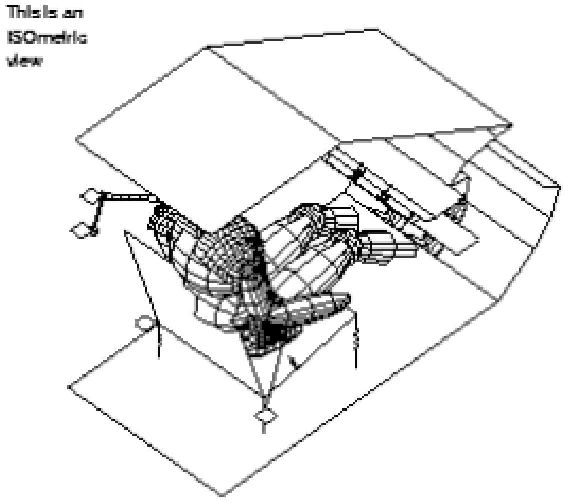
All aspects of viewing are controlled from within the "Viewing and Drawing Control" box. Its layout is shown on the right.

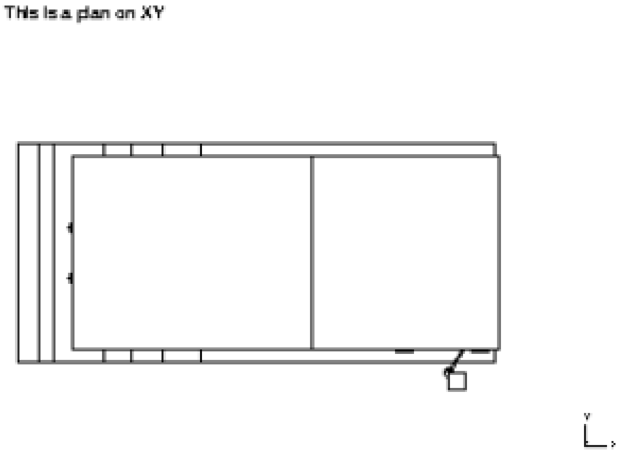
8.2.1 Pre-programmed views.

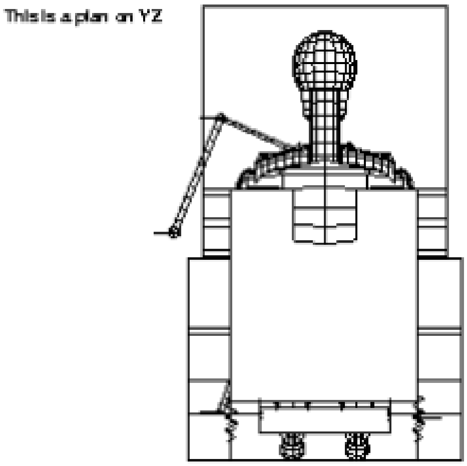
+/-XY Is a plan on model XY, looking down/up Z.
+/-XZ Is a plan on model XZ, looking down/up Y,
+/-YZ Is a plan on model YZ, looking down/up X,
+/-ISO Is an isometric view (equal angles for X,Y,Z).
These views are also available from shortcut keys 1,2,3 etc.

Click here to view as pdf.







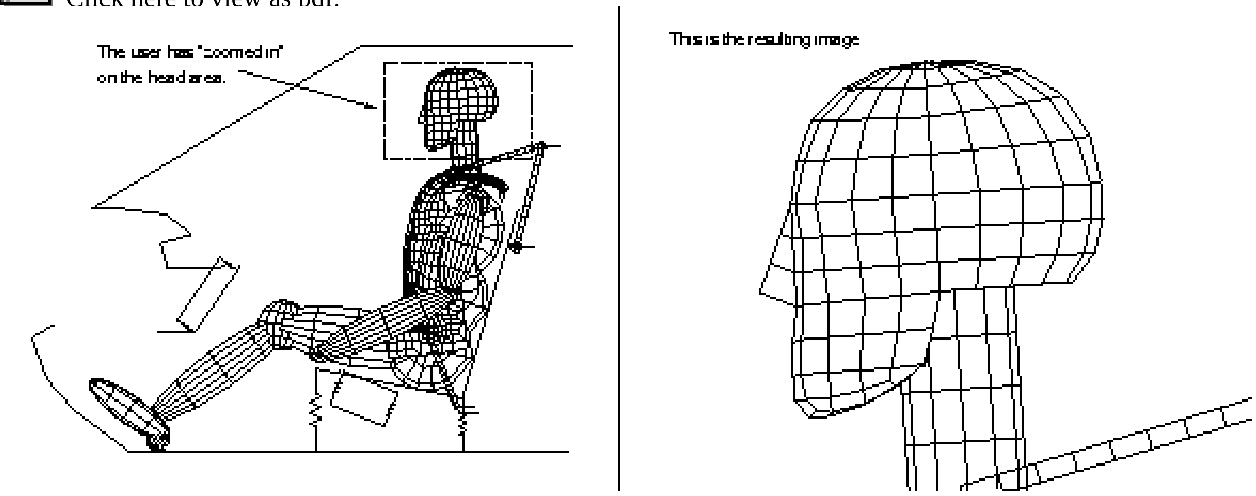


These views only apply rotations, they do not affect scale or position.

8.2.2 "Zooming in" (magnifying an area).

ZMZooms in by using the cursor to pick a rectangular screen area that is to be enlarged to fill the screen (also available from shortcut key Z).

Click here to view as pdf.


The user has "zoomed in" on the head area.
This is the resulting image

Both the scale and the current image centre are changed.

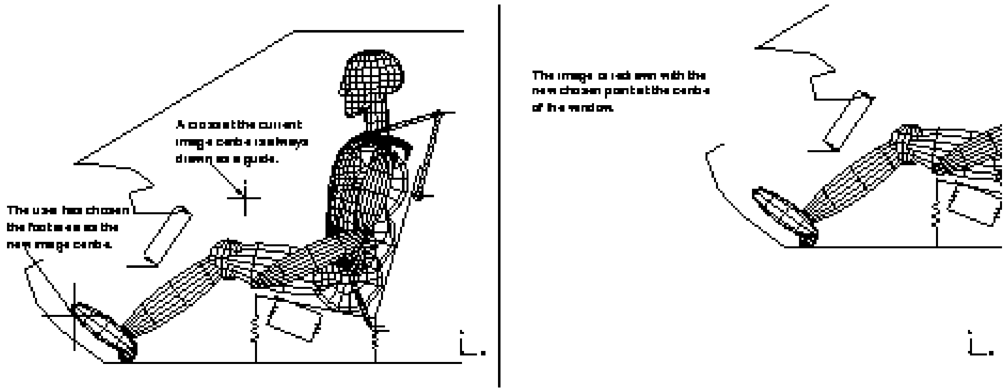
When defining the rectangle with the cursor you can "rubber-band" the box by picking its first point, then pressing the button and moving to see the effect of the second point.

8.2.3 "**CeN**tre" (Centre Node).

CN Lets you choose a new node that will become the new image centre and about which rotations will be performed.

The point chosen with the cursor moves to the window centre, but the scale is not changed.

Click here to view as pdf.


A cross at the current image centre is always drawn as a guide.
The user has chosen the foot area as the new image centre.
The image is redrawn with the new chosen point at the centre of the window.

8.2.4 **AC** (Autoscale Current) Scaling the view to fit the screen

ACCalculates the correct scale and centre position required to make the current image fit neatly onto the screen (also available as shortcut key A). This takes account of blanking, clipping, deformations, etc.

8.2.5. Zooming in using +/-

Shortcut keys + and - magnify/reduce the current view.

8.2.6 Scrolling through previous views

The B ⬅ and F ➡ buttons allow scrolling through previous views.

8.2.7 Blanking control buttons

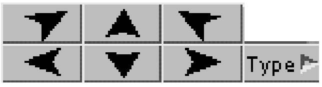
Rev reverses all blanking (or use shortcut key R). **Lock** stores the current blanking status. **All** restores the last stored blanking status.

8.2.8 Other buttons on the Viewing Control panel

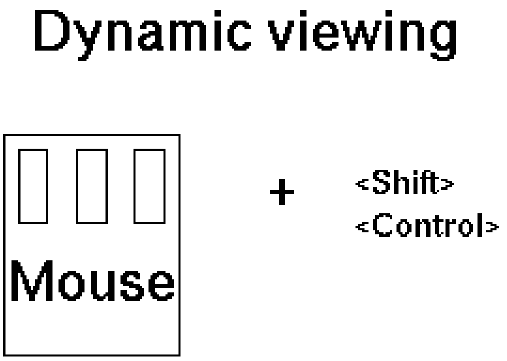
Manual invokes the on-line manual. **Stop** interrupts the current operation. Click here to see a description of **Tidy**.

8.2.9 Alternatives to the commands in this section.

The commands listed here are useful for making explicit changes to the view of your model, for example to set it to a view exactly co-incident with axis orientation or locate its centre at a specific position. However there are two other ways of making these changes which, in some contexts, may be better:



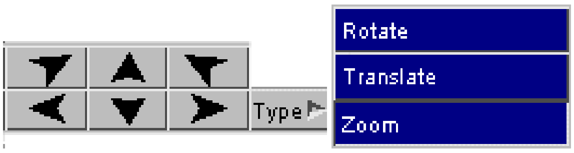
Compass Rose



The "Compass Rose" is described in section 8.3, and dynamic viewing in 8.4.

8.3 Using the "Compass Rose"

The "Compass Rose" provides three sets of buttons that allow the model to be rotated, translated and scaled with single mouse clicks.



8.3.0 General information on using the Compass Rose

The Compass Rose operates in one of three modes selected by the **Rotate**, **Translate** and **Zoom** buttons available from the **Type** pop-up menu as shown in the example above (**Rotation** mode is selected). The options provide:

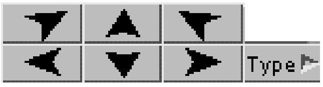
Rotate Arrow buttons provide pre-defined increments of rotation about each of the X,Y,Z axes in screen or model space.

Translate Arrow buttons provide pre-defined increments of translation in each of the X,Y,Z axes in screen or model space.

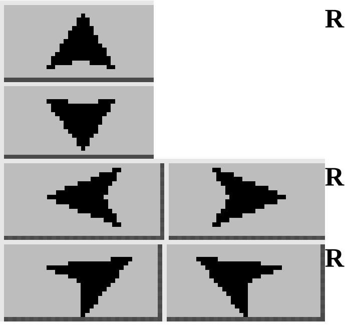
Zoom Buttons provide pre-defined increments of magnification and reduction of viewing scale.

Also, a single click on a function button will deliver a single instance of that function; but holding the button down will, after an initial delay (see Settings), cause it to repeat its function at a pre-defined rate.

8.3.1 Rotation functions.



The arrow buttons have the following meanings:



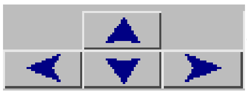
Rotates about *x* axis

Rotates about *y* axis

Rotates about *z* axis

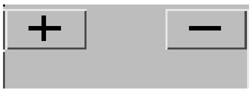
Each click generates an increment of rotation about the relevant axis or, if held down, continuous rotation.

The sign of the rotation is intuitive for system rotations, for example => gives clockwise (+ve) rotation.



8.3.2 Translation functions.

The Translation functions are very similar to the rotation ones: translation defaults to screen space, and uses a similar system of arrow buttons.



8.3.3 Magnification functions

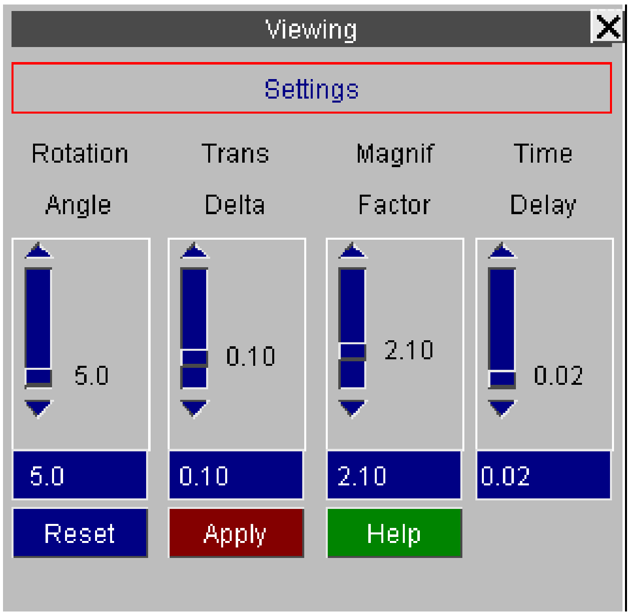
The Magnification function is very simple:

+ Increases the size of the image by the pre-defined increment;
-- Decreases it by the same increment.

The image is scaled about the current window centre.

8.3.4 Setting attributes

In each case the the option **Settings** in the **Viewing** menu gives access to further options which allow you to modify the pre-defined settings (angular increments, time delays, etc).



The attributes that can be set are:

Rotation Angle Angular increment in degrees. The default is 5 deg, but any value 0.0 < value < 180.0 is valid. The **ANGLE** increment of five degrees is a reasonable value for single clicks, but is really too large to give the impression of smooth rotation under continuous motion: you will probably find that a value of 1 or 2 degrees is better for that.

Trans Delta The translation increment as a fraction of screen span. Default is 0.1 (ie 10%), but any value 0.0 < value < 0.5 is valid.

Magnif Factor The magnification factor. Default is 1.1 (ie 10%), but any value 1.0 < value < 5.0 is valid.

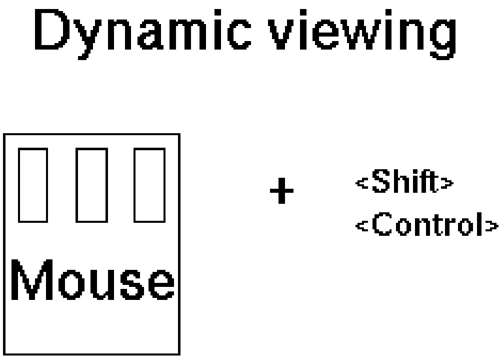
Time Delay Is the time delay (in seconds) between continuous transformations when a button is held down. The default is 0.02s, but values 0.0 <= value < 0.5 are valid. The **Time Delay** is the minimum permitted time delay between frames. If the hardware is taking longer than this to render each frame it does not add to the delay, it simply pads it out if the inter-frame time is shorter than this interval.

You may be tempted to cut the time delay between transformations down to zero, and on very fast hardware (typically 3D machines) this gives good results, but on slower hardware you may find that this gives uneven results as competing system demands lead to variable elapsed intervals between frames. It is for this reason that the delay of 0.02 seconds is the default: it barely slows transformation (50 frames per second is twice as fast as a TV set scans!), but it does even out the delay time between frames giving a smoother result - especially under X-Windows. Experiment on your hardware.

8.4 Dynamic Viewing (Using the mouse to change views).

"Dynamic" viewing is the name given to the process in which you perform viewing transformations by moving the mouse around the screen. This is the final, and probably most useful, way of controlling views described in this section.

The three classes of transformation available in the compass rose (rotation, translation and scaling) are all available in dynamic viewing as well. However rotation and translation are only available in "screen" space: it would be too confusing to try to relate cursor movement to "model" space transformations.



8.4.0 Graphics modes during dynamic viewing

All dynamic viewing operations require a combination of two screen "meta" keys, (**<left control> and <left shift>**), and mouse buttons. The meta key(s) used dictates the graphics mode in which the image is transformed as follows:

<left shift> + <mouse> Transforms the image in the current graphics mode. For example if it is a hidden-line plot, then dynamic viewing will take place in hidden-line mode.

<left control> + <mouse> Transforms the image in "wire-frame" mode for the duration of the drawing operation. (ie no hidden-surface removal or lighting.)

<left shift> &}<left control>} + <mouse> Transforms the image in pre-computed free-edge mode for the duration of the drawing operation. (ie wire-frame of free edges only, no hidden-surface removal or lighting.)

In the latter two cases the original drawing mode is always returned to at the end of the dynamic viewing operation. The wire-frame and free edge modes are provided to make transformations quicker for very large models and/or slow computers: free edge is very fast.

For the last case, with **<left shift>** & **<left control>** held down together, the order of pressing and releasing the meta-keys matters: press **<left shift>** before **<left control>,** and release in the opposite order, otherwise you will (correctly) get the image redrawn in wire-frame mode as the **<left control>** key is pressed and released.

8.4.1 Dynamic Rotation.

Dynamic rotation uses **<left mouse>** + **<left shift>** &/or **<left control>**

(The distinction between the keyboard meta-keys is explained in section 8.4.0 above.)

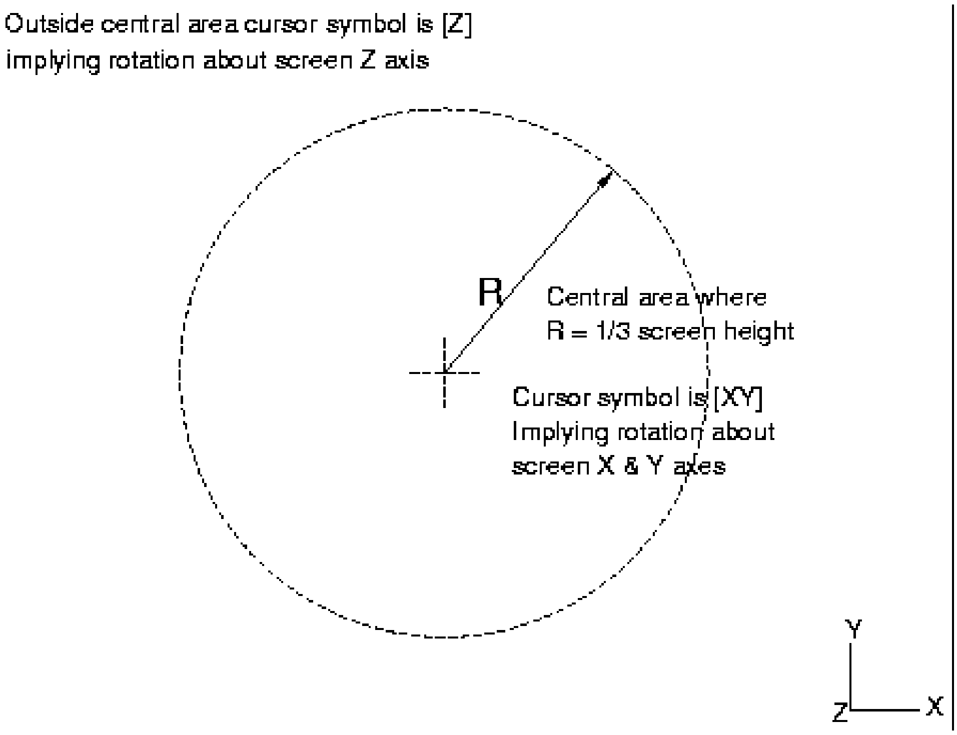
Rotation always take place in the screen coordinate system, and may be about the XY axes or Z: this depends upon the starting position of the mouse. This is shown in figure 8.4.1:

If the mouse initial position is *inside* the central circle (radius (screen height/3)) then rotation is about screen XY axes.

If the initial position is outside this circle then rotation will be about screen Z.

You can tell which mode you are in by the cursor symbol. This red, and:

XY rotation uses **[XY]**
Z rotation uses **[Z]**

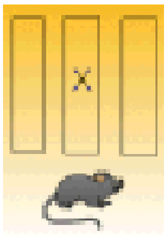


The relationship between mouse and image motion is intuitive in both modes. It is as if you had grabbed a point on the object near you, (this side of the object centre plane), and used this to move the image about its centre:

XY mode Moving the mouse left/right rotates about the screen Y axis;

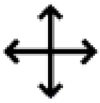
Moving the mouse up/down rotates about the screen X axis.
Z mode Moving the mouse in a circular direction rotates about the screen Z axis.
Rotation remains locked in its initial XY or Z mode for the duration of a dynamic viewing operation, regardless of where you subsequently move the cursor to, until you release a mouse or keyboard button.

8.4.2 Dynamic Translation.



Dynamic translation uses **<mid mouse>** + **<left shift>** &/or **<left control>**

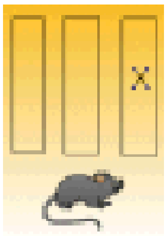
(The distinction between the keyboard meta-keys is explained in section 9.4.0 above.)

The cursor symbol is yellow, and looks like: 

Translation always take place in the screen coordinate system, in the X and Y directions.

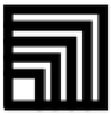
The relationship between mouse and image motion is intuitive: the object tracks the mouse motion in the screen XY plane. The initial position of the mouse is irrelevant.

8.4.3 Dynamic Magnification (Scaling).



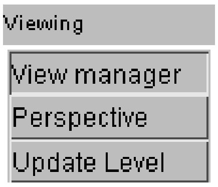
Dynamic scaling uses **<right mouse>** + **<left shift>** &/or **<left control>**

(The distinction between the keyboard meta-keys is explained in section 9.4.0 above.)

The cursor symbol is green, and looks like: 

Mouse motion to the right and down makes the image larger, left and up smaller. The initial position of the mouse is irrelevant.

8.5 Further commands in the Viewing Menu



The following commands with sub-menus in this box are described:

View manager... Storing and retrieving views (this can also be accessed from the button **Views** in the Drawing and Viewing Box).

Perspective... Controlling perspective

Update Level... Setting plot update frequency

8.5.1 VIEWS... Storing and retrieving "view" information.

What is a view?

A "view" is all the information required to set up the current view of the object. In practice this means:

- The current rotation matrix (3 direction cosines).

- The current image centre location in space (x,y,z coordinate).

- The current magnification scale.

- The current perspective distance.

Up to 100 such views may be stored and retrieved at will from a file, and any number of such files may exist. A view is given a name and number when it is stored, and these are used when retrieving it

Views are stored parametrically.

What this means is that views are not tied to a particular model, they will work for any model of similar dimensions. So if you are working on a set of variants of an analysis you can share the views on file between them: this is why they are stored in a separate, model-independent file. It is only when the shape and/or size of a model differs wildly from the original from which the view was created that this shareability fails.

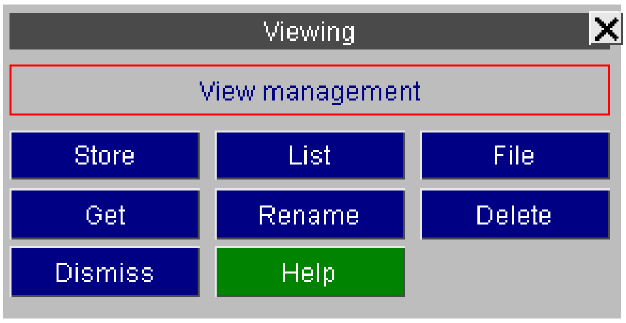
Using views

FOLDER always has a current "view" definition. This dictates how the image will appear when a drawing command is issued. You can save the current view to file at any time. Likewise you can retrieve a stored view to replace the current one at any time.
The current view only exists in memory, and changing it has no influence on any views stored on file. (Indeed you don’t need to have a stored view file: the default is none.)

Managing views

When you press the **Views**... button you get the View Management panel shown in figure 8.5.1(a).

The controls are described below.

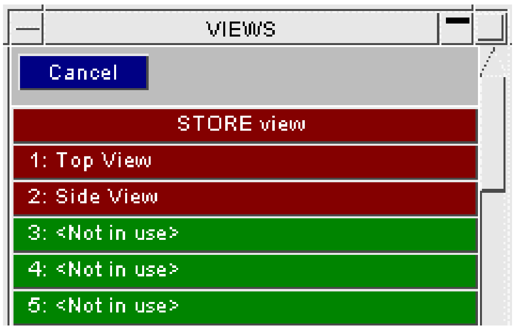


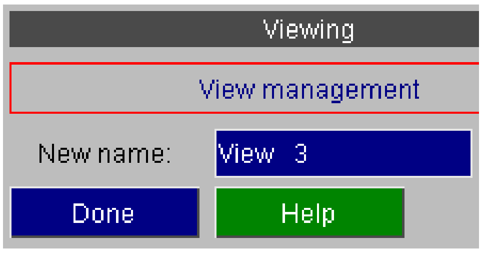
8.5.1.1 **STORE** Storing the current view on file.

You are presented with the **STORE** view menu showing views 1 to 100, and you must choose which one this view is to be stored as.

Views currently in use are red, with their current names shown; unused views are green, and marked **<Not in use>**.

Once you have defined the view number, then give a name. A default name of **"View <n>"** is provided, but any name is valid.

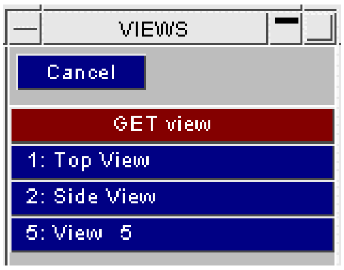




New name: View 3

Up to 100 views can be stored in a file, and views can be overwritten at will. If no explicit file has been opened the default file plot.view is opened automatically and used.

8.5.1.2 **GET** Retrieving a view from file.



You can only retrieve from file views that already exist.

You are presented with the **GET** view menu of stored views, and must pick one. In this example three views are available.The attributes of the stored view are converted from parametric form to your model’s coordinate system, and then become the current view.

If the **`UPDATE_LEVEL`** is 2 or above (see section 9.5.3) then the view takes effect immediately, otherwise it becomes effective the next time you issue a drawing command.

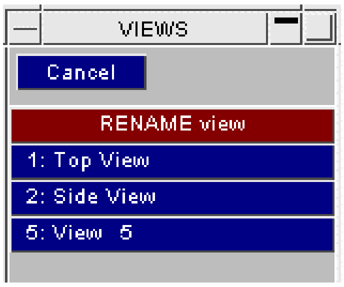
8.5.1.3 **RENAME** Renaming stored views.

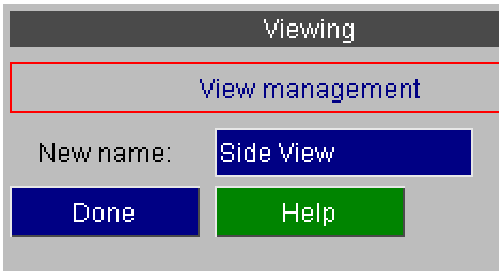
You can rename any stored view.

Select a view from the **RENAME view** menu, then give it a new name.

Any (or no) name is acceptable. This is simply a label by which the view is known.

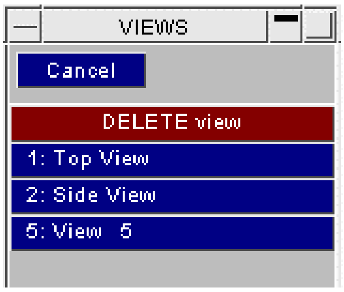
Here the user has chosen to rename view #2, currently called "Side view".





New name: Side View

8.5.1.4 **DELETE** Deleting stored views.



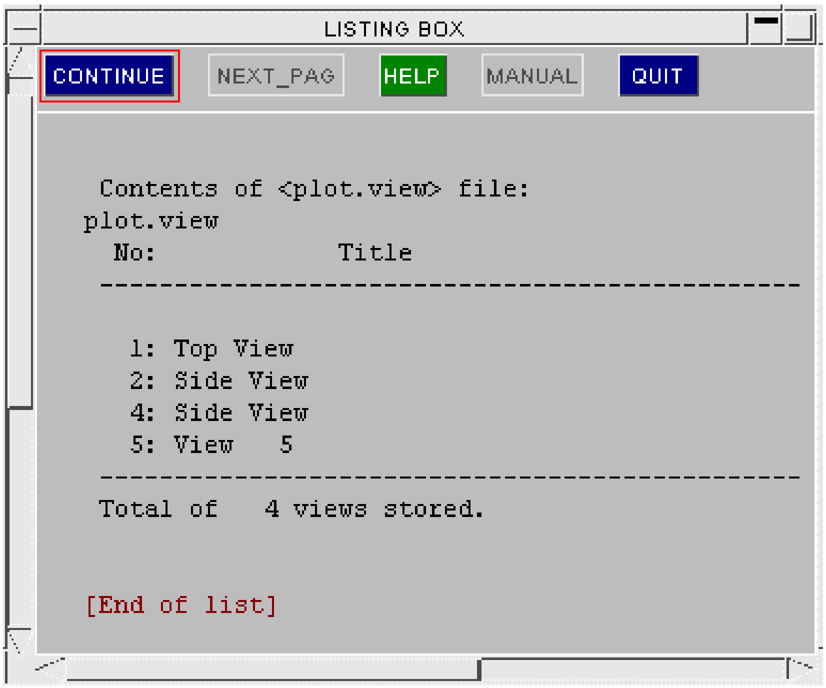
You can only delete existing views. Select a view from the **DELETE** view menu, and it will be deleted.

There is no warning or confirmation dialogue, so make sure that you want to do this! **CANCEL** can be used to abort the operation.

8.5.1.5 **LIST** Listing stored views

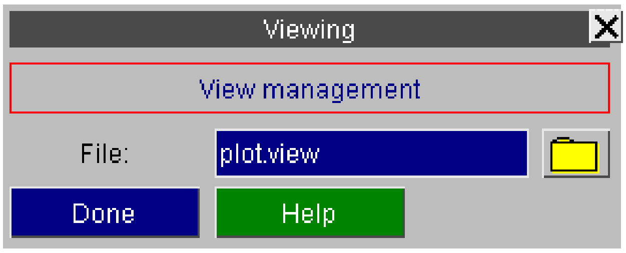
You can list information about stored views to screen with the **LIST** option.

If you have a lot of views this is a better way of listing them than trying to use the menus in a confined space.



```
 Contents of <plot.view> file:
plot.view
  No:            Title
 -----------------------------------------------

   1:  Top View
   2:  Side View
   4:  Side View
   5:  View   5
 -----------------------------------------------
 Total of   4 views stored.


[End of list]
```

8.5.1.6 **FILE** Selecting/Defining a View Storage filename



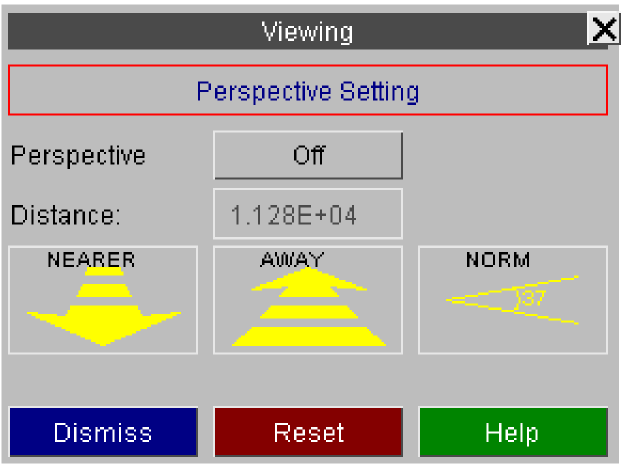
File: plot.view

By default views are stored in a file called plot.view, and generically the view storage file is referred to as the **`<plot.view>`** file.

However you may choose any filename, and you may have any number of view storage files. To open a new or existing **`<plot.view>`** file use the **FILE** command, and enter a new filename.

To use the file filter click the button to the right of the field.

8.5.2 **PERSP**... Setting Perspective Attributes.



Perspective Off

Distance: 1.128E+04

By default perspective in FOLDER is off.

Figure 8.5.2(a) shows the perspective control panel in this default state. Note that the distance changing options are greyed out as a consequence of perspective being turned off.

Figures 8.5.2(b) and (c) show the effect of turning perspective OFF and ON for a rectangular box. In the left image, where perspective is off, the image is foreshortened and looks strange; in the right image, with it on, the box looks more normal.

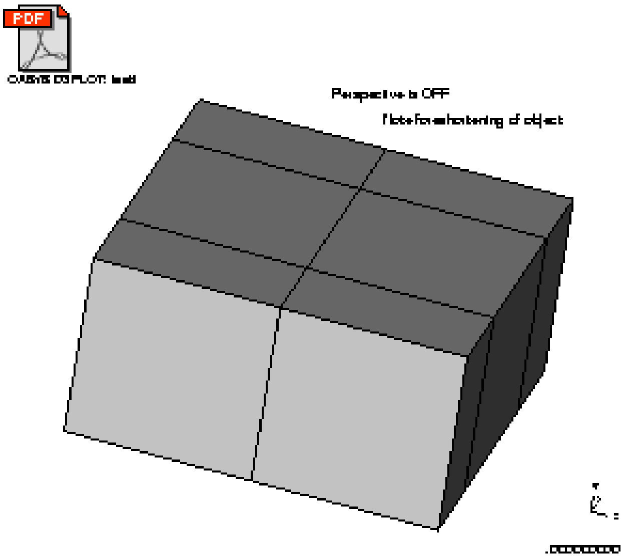


Figure 8.5.2(b): Perspective OFF

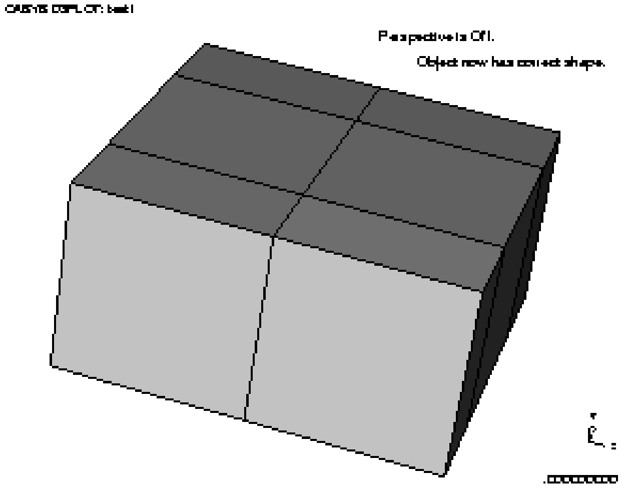
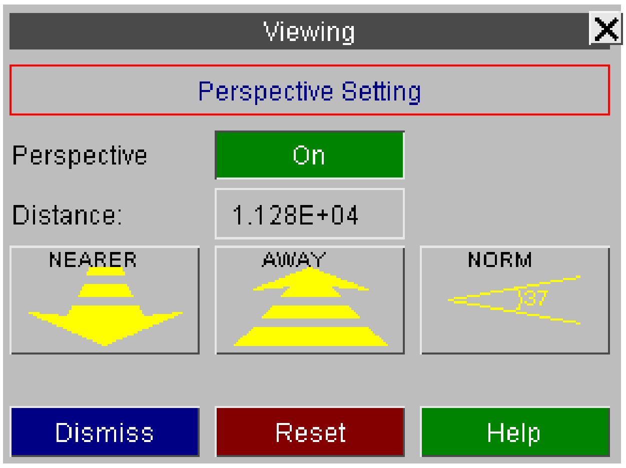


Figure 8.5.2(c): Perspective ON

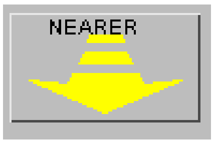
The figure on the right shows the control panel when perspective is turned **ON.**

Note that the distance changing options are now live. These are used as follows.



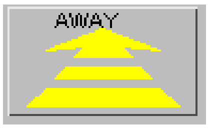
Perspective On

Distance: 1.128E+04



NEARER Reducing perspective distance.

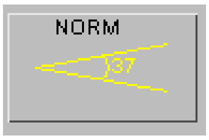
Clicking on this button reduces the perspective distance by 5%. This brings the viewer closer to the object.



AWAY

Increasing perspective distance.

Clicking on this button increases the perspective distance by 5%. The takes the viewer further away from the object.



NORM

Restore perspective distance to its **NORM**al value

This button restores the perspective distance to its standard setting, which gives a field of view of about 37 degrees.

For all three buttons above the effect is immediate if the **UPDATE_LEVEL** (see section 8.5.3) is 2 or greater. In addition holding down a button gives a repeated action after an initial delay, so that you can, in effect, see the effect dynamically as you change the distance.

Setting the distance explicitly.

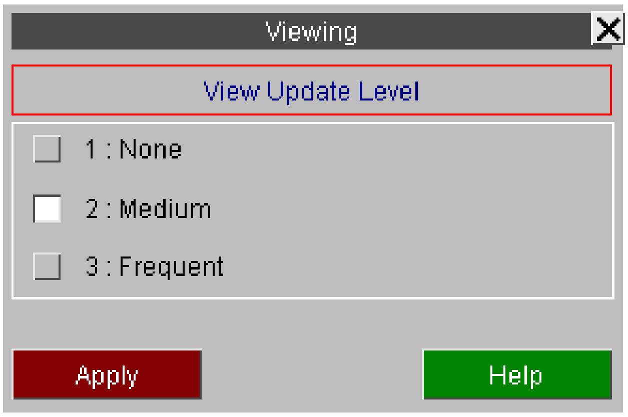
Distance: 9000.0

You can type in an explicit Distance from the observer.

8.5.3 **UPDATE**... Controlling the View updating frequency.

FOLDER has an **UPDATE_LEVEL** setting which dictates how often the view is updated following commands that change it.

This figure shows the **UPDATE** panel and its three settings. These have the following meanings:



Viewing

View Update Level

□ 1 : None

□ 2 : Medium

□ 3 : Frequent

UPDATE_LEVEL = 1 **No updates**

The plot is never updated automatically. Changes only become apparent when you issue an explicit drawing command, eg **DR, CT**, etc.

UPDATE_LEVEL = 2 **Medium updates**

The plot is updated immediately when any view control command is given.

The current image is amended as necessary following blanking, clipping, etc if any viewing command, including dynamic viewing, is used. In other words a viewing change command is tantamount to an explicit redraw command in the current mode which would, of course, reflect any changes in the model geometry.

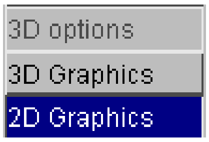
UPDATE_LEVEL = 3 **Frequent updates**

The plot is updated immediately as at level 2 above, but also following any blanking, clipping, etc, command that would change the image if explicitly redrawn.

Therefore the effects of blanking, etc are seen immediately.

Note 1 The default setting is 2 on a windows device.
Note 2 Level 3 is only recommended if you have a very fast display and/or a small model
since it requires frequent redraws.
Note 3 Users with slow devices and/or with large models may find that level 1 is preferable to decrease redrawing effort.

8.6 Special 3D graphics driver options.



On a 3D graphics driver special 3D-only viewing options become available, (greyed out under 2D), as shown here.

8.6.0 Brief description of 3D vs. 2D graphics.

In 2D mode FOLDER treats the display device as a dumb 2D device on which lines, polygons and text can be drawn. All coordinates are expressed in 2D integer space, ie [x,y] only, and all calculation of hidden-surface removal, lighting, etc must be done in software. Dynamic viewing relies on the software recalculating and redisplaying images quickly.

In 3D mode much more intelligence is available in the graphics driver, and much of the effort of computing images can be shifted from the software to the hardware. In particular:

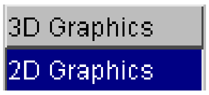
- Graphics coordinates exist in 3D [x,y,z] space, and the hardware does the transformation and projection onto the 2D screen. The software only has to provide the raw coordinates for an image once, and thereafter to change the view only a new scale, centre and rotation matrix.
- The hardware can compute shading, lighting and hidden-surface removal. So, again, the software only needs to provide raw coordinates, topology, light source data, etc, and then just ask the hardware to render it.
- The hardware can provide functions, such as Z-clipping, that are not available in software.

So 3D devices, especially those with hardware acceleration, give much faster graphics.

However there are also drawbacks to using 3D graphics: more memory is required since the full scene has to be sent to the driver using [x,y,z] floating-point coordinates. In addition laser plots cannot be generated by the 3D driver, so the capability to switch temporarily back to 2D mode has to be preserved.

Therefore there are options to control aspects of 3D graphics, and also the ability to switch back and forth between 3D and 2D modes.

8.6.1 Switching between 3D and 2D modes.



You can switch explicitly between 2D and 3D modes using the **3D Graphics** and **2D Graphics** buttons.

Some other graphics options also cause a switch.

On a 3D graphics driver the default mode is 3D, but certain graphics operations will switch the mode back to 2D. These are:

- Switching on dithered shading mode: continues until you switch it back explicitly.
- Plotting with laser output turned on. 2D mode is only transient during the course of the plotting operation, it is switched back to 3D automatically after each plot.

There are other circumstances when you might also want to switch explicitly to 2D mode:

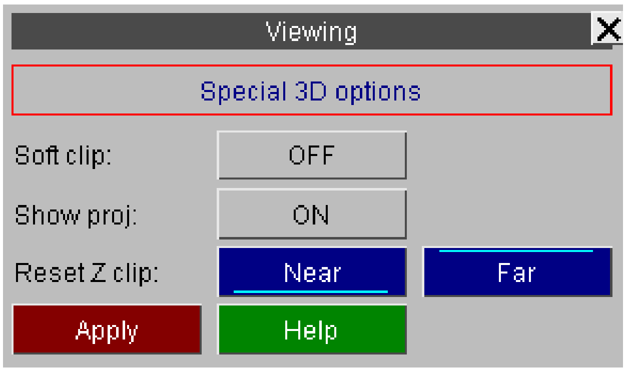
- When producing LC line-contour plots the result in 3D mode can be a bit patchy, with contour lines dropping in and out of view. This is a function of the Z buffering in hardware, and software (2D) images look much better.
- When using the OPACITY switch for contact surface and beam plotting. This works after a fashion when in 3D mode, but the transparent structure overlay does not use proper hidden-surface removal. The results are better in 2D mode where more control is available in the software.
- When animating large models. The amount of data stored for a 2D animation can be far less than for 3D, and can get round memory shortage problems. (However you would do better to use the X-Windows driver in this situation.)

8.6.2 **3D_OPTS...** Further 3D options.

The **3D_OPTS...** button gives a control panel for further 3D options.

The Special 3D options panel is shown in figure 8.6.2.

These options are described below.



Soft clip: OFF

Show proj: ON

8.6.2.1 **Soft clip** Clipping graphics outside the current screen window.

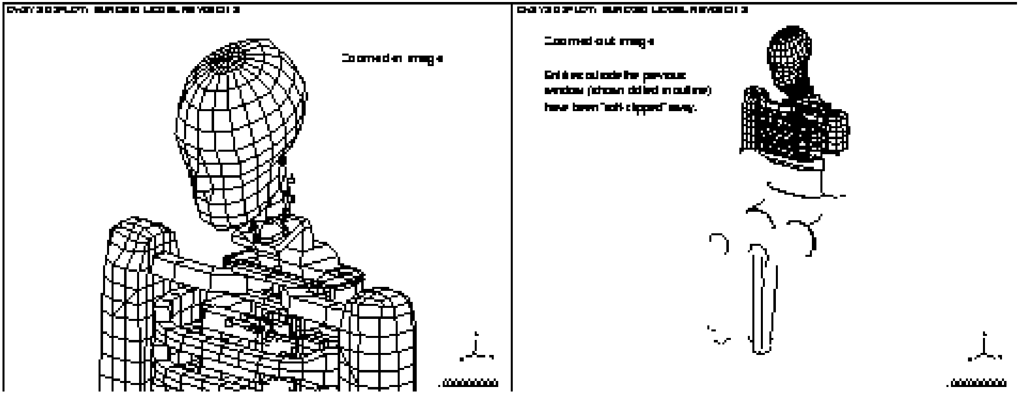
If you are dealing with a very large model, but are only looking at a small part of it, the 3D graphics driver can work unnecessarily slowly in its default mode of operation. This is because the whole model is sent to and manipulated by the graphics driver, despite the fact that you are only looking at a small part of it, in anticipation of your wanting to zoom out to see the whole of it.

If you turn Soft Clip on, and redraw the image, the graphics will run faster. This is because the software has "clipped" (ie removed) those parts of the image not visible in the current window before sending it to the 3D graphics driver, so the 3D driver has to process fewer graphics entities. However this also means that if you zoom out those parts of the image outside the previous window will not be there. This is illustrated in figure 8.6.2.1(a) and (b).

In this example the user has zoomed in on the neck and upper chest region of a side-impact dummy (left hand image), and then zoomed out to what should show the full dummy. This exposes the jagged edges left by the 3D clipping algorithm.

To see the missing elements you need to issue an explicit drawing command at the new scale to recalculate the clipping and send more elements to the 3D graphics driver.

Click here to view as pdf


Zoomed-in image
Zoomed-out image
Entities outside the previous window (shown dotted in outline) have been "soft-clipped" away.

8.6.2.2 **SHOW_PROJ** Showing the viewing frustrum

On 3D devices it is possible to show the current viewing "frustrum" at the bottom left corner of the plot by turning **SHOW_PROJ** on.

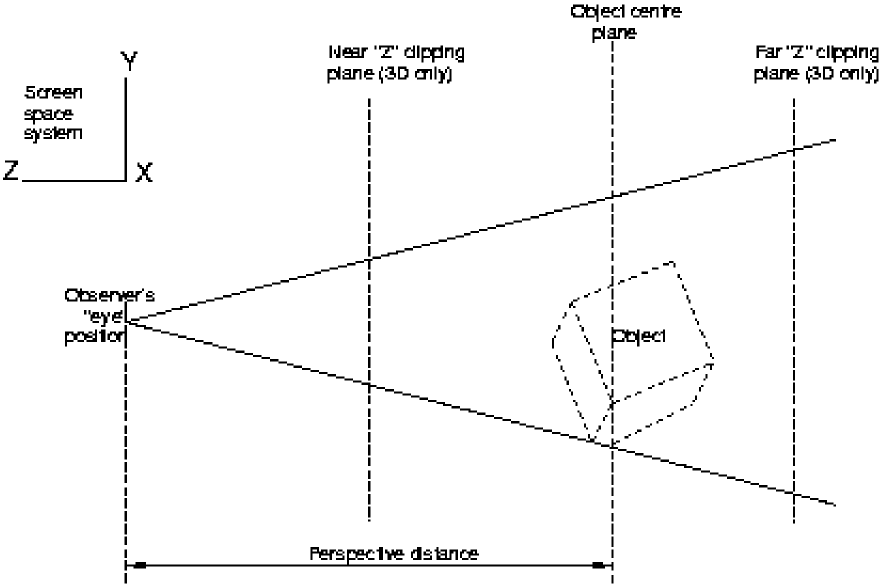
This shows the information in figure 8.6.2.2 (a copy of figure 8.1(b)).

The frustrum shown here assumes perspective projection.

The Z clipping plane locations are shown when **SHOW_PROJ** is on, and this can be very helpful when using Z clipping, as otherwise it is easy to "lose" the clipping planes.

The default near and far plane positions are drawn in green, and the plane locations in blue. So you can visualise movement relative to initial locations.

Click here to view as pdf


Object centre plane
Near "Z" clipping plane (3D only)
Far "Z" clipping plane (3D only)
Y
Screen space system
Z
X
Observer's "eye" position
Object
Perspective distance

8.6.2.3 Using the Z clipping plane

The Z clipping planes are shown in figure 8.6.2.2. There are two planes: a "near" and a "far" one, which the hardware uses to clip the image in the +/- screen Z axis.

By default they are set just outside the +/-Z limits of the structure (shown as green lines in the projection box), so that no clipping takes place, but you can move them (shown as blue lines in the box) using the following mouse and keyboard meta-key combination:

<right shift> + <left mouse> Moves the near clipping plane.

Cursor symbol is

<right shift> + <right mouse> Moves the far clipping plane

Cursor symbol is

<right shift> + <mid mouse> Moves the both clipping planes

Cursor symbol is

In all cases moving the mouse up moves the plane(s) away from you, and down moves towards you. This is a form of dynamic viewing: the planes move and the image gets updated as the cursor moves. It is recommended that you turn the **SHOW_PROJ** switch, described above, on as this will enable you to see the planes moving in the projection box.

To reset the planes to their default positions use the Reset Z clip **NEAR** and **FAR** buttons. This will reset them to their initial positions (shown by the blue lines in the projection box).

APPENDICES

APPENDIX I: Standard Object Names and Acronyms

Inside FOLDER every class of object (membranes, straps, nodes etc...) has a standard "acronym" that is used when labelling items on the screen, and which can sometimes be needed when the user types in a specific object label. For example the acronym for a node is "N", thus node 27 will always be labelled as "N27".

In addition, when FOLDER has more than one airbag in memory it is necessary to prefix the object label with its airbag number. The acronym for an airbag is "A", thus if node 27 exists in both models 1 and 3 the two labels will be respectively:

A1/N27	(Airbag #1, Node #27)
A3/N27	(Airbag #3, Node #27)

You only have to remember these when using the **Key in** method of defining objects (section 6.2), and even then only when the object type is not implicit. For example to select node 10 in airbag #1 you will need to "key in":

10	If both object type (NODE), and the airbag id (1) are preset.
N10	If object type is ambiguous, but airbag id is preset.
A1/N10	If neither object type or airbag id are preset

In most situations the <airbag> and <object type> are implicit: either because of the context of the operation, or because of prior selections, or because of "filter" settings, and only numbers are required.

As well as acronyms every object has a "formal" name that is used when referring to it in error messages, diagnostic output, panel buttons, etc.

The complete list of object types, their standard acronyms and their formal names is:

Object type	Standard Acronym	Formal name
Airbag	A	AIRBAG
Element (generic)	EL	ELEMENT
Element Membrane	M	MEMBRANE
Element Additional Mass	AM	ADDITIONAL MASS
Element Strap	S	STRAP
Node	N	NODE
Set (generic)	SET	SET
Set Node	S_NO	SET_NODE
Set Membrane	S_M	SET_MEMBRANE
Airbag "Fold Set"	ORIG	FOLD_SET
Airbag Fold defn	FOLD	FOLD

APPENDIX II: Fold Set "tree" file example

The following is an Fold Set "tree" file example

```
$
$
$
$
*FOLD_SET_START
         1Origami 1
         1         2
$
*AXES
         1
$
*OPTIONS
        80         2         2         2         1
         2        -1         4         5         6         3         7
 1000000.0       1.1       0.9       0.0
$
$ =============
$ List of FOLDs
$ =============
$
$ LINE 1 (Basic data)
$     FIELD 1: LABEL
$     FIELD 2: TYPE
$              =0: NULL
$              =1: THIN
$              =2: THICK
$              =3: TUCK
$              =4: SPIRAL
$              =5: SCRUNCH
$              =6: ALIGN
$     FIELD 3: UPDOWN
$              =0: UP
$              =1: DOWN
$     FIELD 4: RIGHTLEFT
$              =0: RIGHT
$              =1: LEFT
$     FIELD 5: REFERENCE COORDINATE    SET FLAG
$     FIELD 6: LAYERS FOR TUCK FOLD
$     FIELD 7: SUBSET FOLDING
$     FIELD 8: CREATE ALIGN FOLD TRAM    LINES
$
$ LINE 2 ( Reference nodes)
$     FIELD 1: FOLD_NODE
$     FIELD 2: TUCK_ZSPLIT_N1
$     FIELD 3: TUCK_ZSPLIT_N2
$     FIELD 4: LAYER_ZMIN_N1
$     FIELD 5: LAYER_ZMIN_N2
$     FIELD 6: LAYER_ZMAX_N1
$     FIELD 7: LAYER_ZMAX_N2
$
$ LINE 3 (Sets, etc.)
$     FIELD 1: NODES_LEFT
$     FIELD 2: NODES_CENTER
$     FIELD 3: NODES_RIGHT
$     FIELD 4: SHELL_LEFT
$     FIELD 5: SHELL_CENTER
$     FIELD 6: SHELL_RIGHT
$     FIELD 7: TUCK FOLD TYPE
$
$ LINE 4 (Positions, etc.)
$     FIELD 1: THICKNESS
$     FIELD 2: FOLD_XPOS
$     FIELD 3: FOLD_XTOL
$     FIELD 4: INPLANE_ANGLE
$
$ LINE 5 (Fold specific data)
$     FIELD 1: Factor for unused portion    of spiral.
$     FIELD 2: Out-of-plane fold angle.
$     FIELD 3: Scale factor for fold    point separation.
$     FIELD 4: Location of ZSPLIT    for tuck.
$
$ LINE 6 (Layering and align data)
$     FIELD 1: Minimum value for layer.
$     FIELD 2: Maximum value for layer.
$     FIELD 3: Tramline offset distance    for align.
$
$ LINE 7 (Reference point.)
$     FIELD 1: X.
$     FIELD 2: Y.
$     FIELD 3: Z.
$
$ LINE 8 (Local X vector.)
$     FIELD 1: X.
$     FIELD 2: Y.
$     FIELD 3: Z.
$
$ LINE 9 (Vector in X-Y plane.)
$     FIELD 1: X.
$     FIELD 2: Y.
$     FIELD 3: Z.
$
$*FOLD
         1         3         0         0         1          0         0
0
       314         0         0         0         0          0         0
         2         2         2         1         1          1         0
                 5.0           114.50000                  0.0
0.0
        0.10000000               180.0                    1.0
0.0
      -1.0000000E+20       1.0000000E+20                  0.0
                 0.0                 0.0                  0.0
                 1.0                 0.0                  0.0
                 0.0                 1.0                  0.0
$
*FOLD
         2         3          0         1         1         0         0
0
      1729         0          0         0         0         0         0
         2         2          2         1         1         1         0
                 5.0          -114.50000                 0.0
0.0
        0.10000000                180.0                  1.0
0.0
      -1.0000000E+20        1.0000000E+20                 0.0
                 0.0                  0.0                 0.0
                 1.0                  0.0                 0.0
                 0.0                  1.0                 0.0
$
*FOLD
         3         1          0         1         1         0         0
0      2343         0          0         0         0         0         0
         2         2          2         1         1         1         0
                 5.0          -36.750000                 0.0
90.0
        0.10000000                180.0                  1.0
0.0
      -1.0000000E+20        1.0000000E+20                 0.0
                 0.0                  0.0                 0.0
                 1.0                  0.0                 0.0
                 0.0                  1.0                 0.0
$
*FOLD
```

```
        4          1          0         0         1         0         1
0     5483          0          0         0         0         0         0
2          2          2         1         1         1
5.0            43.100006                 0.0                 90.0
          0.10000000                180.0          0.85000002
0.0
      -1.0000000E+20        1.0000000E+20    0.0
                 0.0        0.0       0.0
                 1.0        0.0       0.0
                 0.0        1.0       0.0
$
*FOLD
        5          1          0         1         1          0         1
0
     2154          0          0         0         0          0         0
        2          2          2         1         1          1         0
                 5.0           -37.799988                  0.0
90.0
          0.10000000                180.0           0.85000002
0.0
      -1.0000000E+20        1.0000000E+20                  0.0
                 0.0                  0.0                  0.0
                 1.0                  0.0                  0.0
                 0.0                  1.0                  0.0
$
*FOLD
        6          2          0         0         1          0         1
0
     3430          0          0         0         0          0         0
        2          2          2         1         1          1         0
                 5.0            14.200012                  0.0
90.0
          0.10000000                 90.0           0.85000002
0.0
      -1.0000000E+20        1.0000000E+20                  0.0
                 0.0                  0.0                  0.0
                 1.0                  0.0                  0.0
                 0.0                  1.0                  0.0
$
*FOLD
         7         6          0         1         1          0         0       1
         0         0          0         0         0          0         0
         2         2          2         1         1          1         0
                 5.0                 60.0                  2.0
90.0
          0.10000000                 90.0           0.85000002
0.0
      -1.0000000E+20        1.0000000E+20                  5.0
                 0.0                  0.0                  0.0
                 1.0                  0.0                  0.0
                 0.0                  1.0                  0.0
$
*FOLD
        8          1         0          0         1          0         0        1
      267          0         0          0         0          0         0
        2          2         2          1         1          1         0
                 5.0                 60.0                  2.0
90.0
          0.10000000                 90.0           0.85000002
0.0
      -1.0000000E+20        1.0000000E+20                  5.0
                 0.0                  0.0                  0.0
                 1.0                  0.0                  0.0
                 0.0                  1.0                  0.0
$
*FOLD
        9          4         0          0         1          0         0        1
      629          0         0          0         0        110      3577
        2          2         2          1         1          1         0
                 5.0            30.449997                  2.0
0.0
                 2.0                 90.0           0.85000002
```

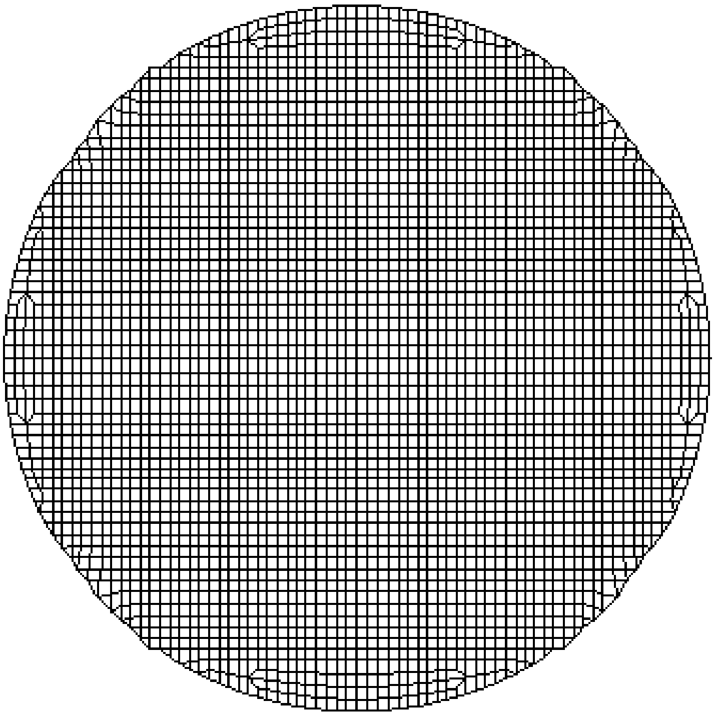
```
0.0
      -1.0000000E+20            7.4999962                  5.0
           71.000008            62.500000            80.000008
                 0.0                  0.0                  1.0
                -1.0                  0.0                  0.0
$
$ ===============
$ List of ORIENTs
$ ===============
$
$ LINE 1
$     FIELD 1: LABEL
$     FIELD 2: TYPE
$              =0: TRANSLATION
$              =1: ROTATION
$              =2: SCALE
$     FIELD 3: TRANSLATE/ROTATE TYPE
$              =0: X
$              =1: Y
$              =2: Z
$              =3: vector
$              =4: N1->N2
$     FIELD 4: SCALE TYPE
$              =0: X,Y,Z
$              =1: N1,N2,N3
$     FIELD 5: N1
$     FIELD 6: N2
$     FIELD 7: N3
$     FIELD 8: CENTRE NODE
$
$ LINE 2
$     FIELD 1: TRANSLATE DISTANCE    TYPE
$              =0: MAGNITUDE OF VECTOR
$              =1: USER DEFINED
$     FIELD 2: USER DEFINED DISTANCE
$     FIELD 3: ROTATE/SCALE CENTRE    TYPE
$              =0: GLOBAL AXIS
$              =1: COORDINATE
$              =2: NODE
$              =3: N1
$     FIELD 4: CENTRE[X]
$     FIELD 5: CENTRE[Y]
$     FIELD 6: CENTRE[Z]
$     FIELD 7: ANGLE
$
$ LINE 3
$     FIELD 1: VECTOR[X]
$     FIELD 2: VECTOR[Y]
$     FIELD 3: VECTOR[Z]
$     FIELD 4: SCALE[X]
$     FIELD 5: SCALE[Y]
$     FIELD 6: SCALE[Z]
$
$
*ORIENT
         1         0         0         0         0          0          0
0
         0     100.0         0       0.0       0.0        0.0        0.0
       1.0       0.0       0.0       1.0       1.0        1.0
$
*ORIENT
         2         1         0         0         0          0          0
5726
         0       0.0         2       0.0       0.0        0.0       45.0
       1.0       0.0       0.0       1.0       1.0        1.0
$
*ORIENT
         3         0         4         0      4102       4008          0       0
         1      50.0         0       0.0       0.0        0.0        0.0
       1.0       0.0       0.0       1.0       1.0        1.0
$
```

```
*ORIENT
         4         2         0         1      4099       4005       4096    3803
         0       0.0         2       0.0       0.0        0.0        0.0
       1.0       0.0       0.0       1.0       0.8        1.0
$
*FOLD_SET_END
```

It is strongly recommended that you don’t attempt to edit Fold Set files by hand, as it can be very hard to identify exactly what the individual numbers mean. To change folds or orients read them back into FOLDER and edit them there.

Also, try not to separate Fold Set definitions from their parent input decks: they reference SET and other entities within these decks, and confusion will arise if these labels are not treated consistently.

APPENDIX III: Airbag Folding example



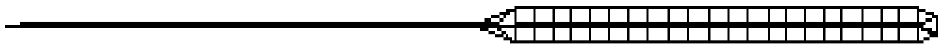
The following example is of a somewhat simplified geometry of an airbag. This is designed to provide a fairly complete demonstration of the capabilities to make a folded airbag. It is not designed to represent a realistic fold pattern or to represent accurate deployment of an airbag.

Figure A3.1 shows the starting geometry for this model. The units are in millimetres and the fabric is 0.25mm thick. The airbag is a simple drivers side (or pancake) airbag.

The first issue in folding this model is to create an ORIGAMI. This is done by selecting **DEFINE_ORIGAMI** and then **CREATE.** When choosing the materials, it is important to select only the materials which are to be folded. In this case the whole model is wanted for folding so **WHOLE MODEL** can be used to select the entire model. **SELECT** the ORIGAMI and press **SET_FOLD** to start folding the airbag.

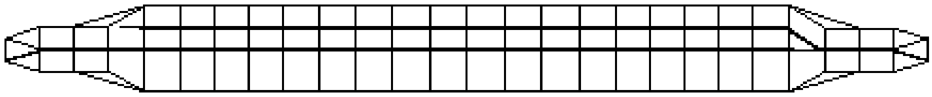
The folding pattern consists of 9 folds. The folds are:

1. Tuck fold along x-axis
2. Tuck fold along x-axis (interferes with first fold)
3. Thin fold along y-axis
4. Thin fold along y-axis using subset folding
5. Thin fold along y-axis using subset folding
6. 90 thick fold along y-axis
7. Align fold using tramlines
8. 90 thin fold along y-axis
9. Spiral fold using a local coordinate system and layers

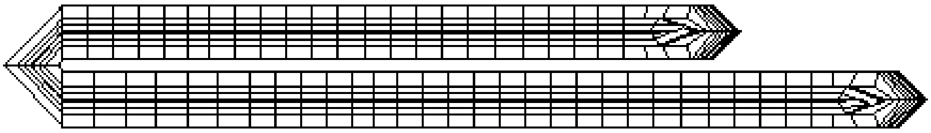


The first fold is a tuck fold. The fold is in the x direction and in the xy plane (the default folding plane). The fold point is at 114.5 and the direction is from right to left. The fold point is defined by selecting a node using the FOLD_POINT button. By default the folder chooses all of the airbag to the right of the fold line. As this is what we want this is OK. Figure A3.2 shows a side view of the airbag after the tuck fold. In this example the fold separation has been set very high (5.0mm) so you can see the tuck fold. In reality the separation would be much smaller (probably the same order as the fabric thickness).

The second fold is defined in exactly the same way except that the direction is from left to right and the fold point is at -114.5. By default the folder chooses all of the airbag to the left of the fold line which is what is required.



A side view after FOLD 2 is shown in Figure A3.3. As the two tuck folds interfere with each other the first tuck fold has been moved so that no penetrations occur. As the fold separation is very large this effect has been exagerated. In reality the amount would be much smaller.



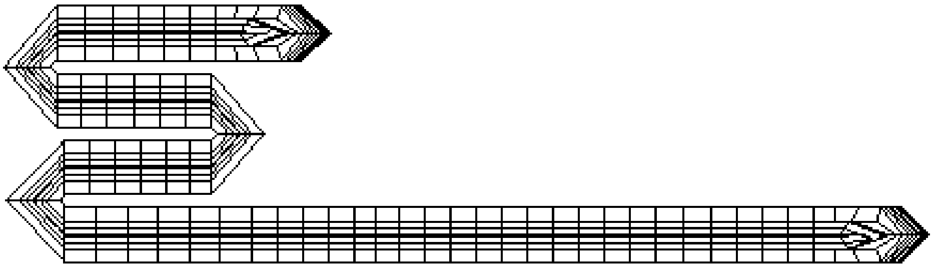
Folds 3 to 5 will show how you can use subset folding to quickly fold an airbag. Fold 3 is a thin fold. We want to fold it in the y direction so a 90 fold angle needs to be selected. Figure A3.4 shows the airbag after this fold has been done.

The fourth fold is a thin fold in the opposite direction. By default the folder will fold all of the airbag which is on one side of the fold line to the other side. In this case we only want to fold the top layer of the airbag in figure A3.4. We have three ways of performing this fold.

1. Defining a set to fold rather than the whole origami
2. Using layers to select a specific vertical range of the airbag to fold.
3. Using subset folding.

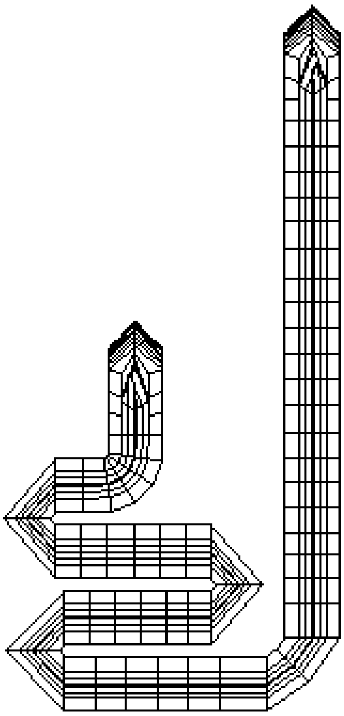
Subset folding is the easiest option to use. We can use this because all the nodes which we want to fold in this fold (4th fold) have been folded in the previous fold (fold 3). i.e these folds are a subset of the previous fold nodes. Press the **SUBSET FOLDING** button. The node selection should autoamtically update to the folds we need. The previous fold was in the left to right direction. This fold needs to be right to left.

The 5th fold is done in exactly the same way. As we are already using subset folding everything (including the fold direction) will be set correctly. Figure A3.5 shows the airbag after the first 5 folds.



Fold 6 can also be done with subset folding. This is to show that subset folding is not just for thin folds. It also works for thick folds. We only want to fold this by 90 instead of 180. This is easily changed by using **THICK FOLD OPTIONS** and changing the angle. Apart from this complication the process is identical to folds 3 to 5.

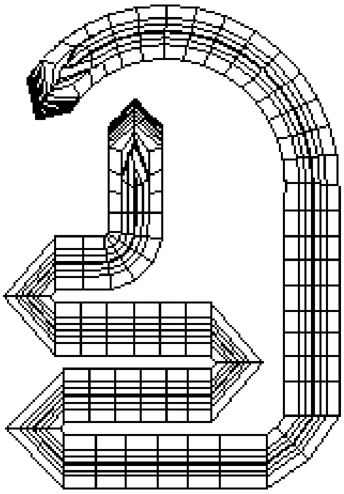
Fold 7 is an **ALIGN** fold. This is used if your nodes are not exactly where you want them to be. In this case we want to make adjacent nodes to the fold line a constant distance of 5mm from the fold line. This is done by setting the fold point as normal. As we were using subset folding in the previous folds we need to make sure that it is turned off as these folds are no longer a subset of the previous fold. To set the align fold options use **ALIGN FOLD OPTIONS** and make sure that the **MAKE TRAMLINES** option is set with a constant distance of 5mm.



Fold 8 is a thin fold of 90. This presents no real problems and is similar to previous fold definitions. Figure A3.6 shows the airbag after the first 8 folds have been done.

The last fold is a spiral fold. This presents problems because the part of the airbag we want to fold does not lie on the xy plane which is the default folding plane for the folder. This can be overcome by defining a local coordinate system for this fold. To do this press **DONE** to exit the **SET_FOLD** menu and return to the main folding window. **LOCAL_SYSTEM** allow you to define a new folding plane. We define a plane which is in the global XZ axis. This is done by selecting N1 somewhere on the vertical part of the airbag where we want to do the spiral fold. N2 is selected so that local x points in the global Z direction. N3 is now chosen so that the 3 points give the local xy plane.

This allows us to define the plane for the spiral fold but if we try to fold this we will fold other parts of the airbag which are on the same side of the fold line. We need to either define a subset of the bag to fold or use layers to specify a range of the airbag to fold. In this case it is easier to define the **UPPER LAYER** so that anything above that local z coordinate is discarded when folding.



Once the airbag has been folded it can be positioned to the desired location using the **POSITION FOLDED BAG** option. This example model has 4 orientations stored with the origami so that the airbag can be repositioned as needed. They can be modified or deleted easily or new orientations can be added just like folds. The 4 orientations that are stored are:-

1. Translation, 100mm along the X axis
2. Rotation of 45 about X, centred on node 5726
3. Translation along vector using N1->N2 method with distance 50mm
4. A scale in a local coordinate system of 0.8 in the Y direction only.

APPENDIX IV: Summary of command-line and Environment Variable settings

The data below has been described elsewhere in this manual, but is summarised below to concentrate it all in one place

Command-line arguments valid in FOLDER

Function	Format	Options
Setting the graphics device By default no graphics device is defined, and the device selection panel is mapped. These options can be especially useful if you want to bypass the device selection panel and always start FOLDER with a particular graphics driver.	`-d=<device>`	`-d=opengl` Use OpenGL 3D graphics `-d=x24` 24 bit-plane X-Windows graphics `-d=x8` 8 bit-plane X-Windows graphics `-d=x` **`X24`** if available, otherwise **`X8`** `-d=default` Whichever is available in the order **`OpenGL`**, **`X24`**, **`X8`**
Specifying "full screen" mode on startup Normally FOLDER occupies about 70% of the display when it starts, the "maximise" argument changes this to become the full screen.	`-maximise`	

Environment variables that affect FOLDER.

Environment variables can be used to influence the behaviour of FOLDER.

Unix/Linux systems running "C" shell (/bin/csh) or its derivatives such as /bin/tcsh:

The format of the command is:

```
setenv <parameter> <argument list>
```

For example:

```
setenv DISPLAY my_machine:0
setenv SM_USE_VISUAL default
setenv DISPLAY_FACTOR 1.2
```

Unix/Linux systems running "Bourne" (/bin/sh) or "Korn" (/bin/ksh) shells

The format of the command is:

```
<parameter>=<argument list>; export <parameter>
```

For example:

```
DISPLAY=my_machine:0; export DISPLAY
SM_USE_VISUAL=default; export SM_USE_VISUAL
DISPLAY_FACTOR=1.2; export DISPLAY_FACTOR
```

Windows systems

Choose the "**System**" panel

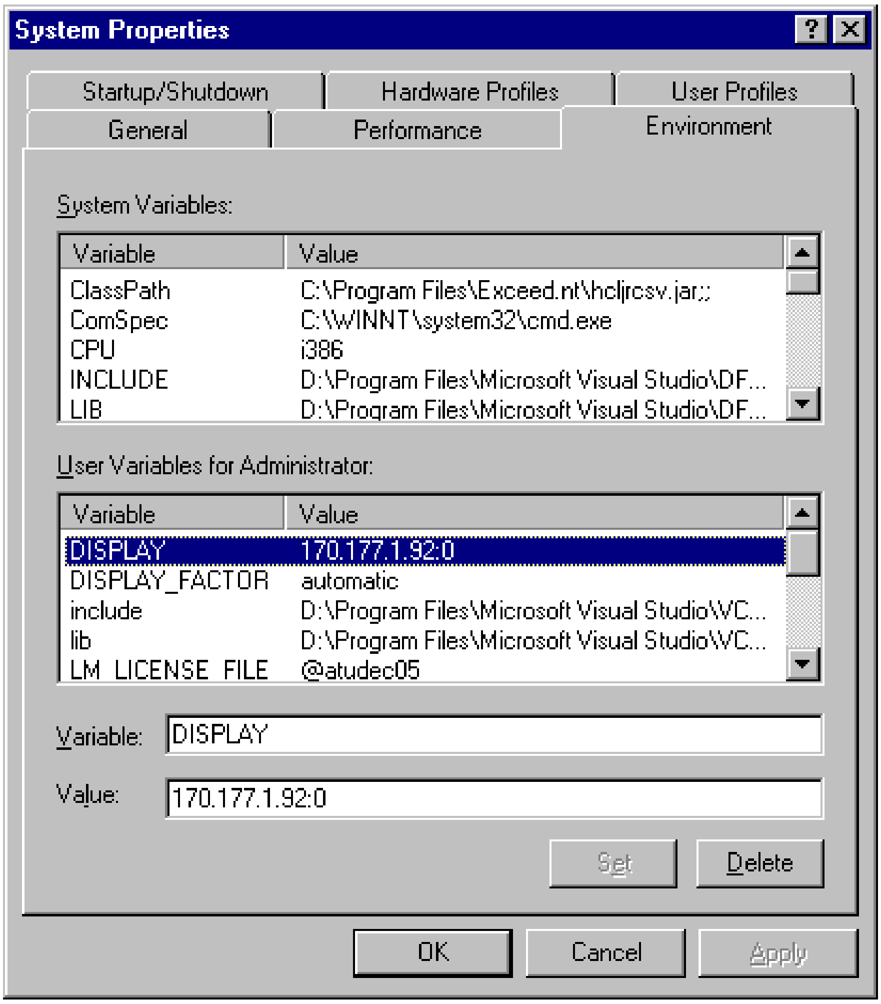
My Computer ==> Control Panel ==> System

On Windows NT:
On Windows 2000 / XP:

My Computer ==> Properties ==> Advanced

Select the **Environment** tab.

(This example shows the panel from Windows NT4. That from Windows 2000 and XP is very similar.)



System Variables:

Variable	Value
ClassPath	C:\Program Files\Exceed.nt\hcljrcsv.jar;;
ComSpec	C:\WINNT\system32\cmd.exe
CPU	i386
INCLUDE	D:\Program Files\Microsoft Visual Studio\DF...
LIB	D:\Program Files\Microsoft Visual Studio\DF...

User Variables for Administrator:

Variable	Value
DISPLAY	170.177.1.92:0
DISPLAY_FACTOR	automatic
include	D:\Program Files\Microsoft Visual Studio\VC...
lib	D:\Program Files\Microsoft Visual Studio\VC...
LM_LICENSE_FILE	@atudec05

Variable: DISPLAY

Value: 170.177.1.92:0

Then insert the relevant **Variable** and **Value** strings into the User or System settings as desired.

In this example it can be seen that iser Administrator has set the **DISPLAY** environment variable to **170.177.1.92:0**.

Environment variables that control the behaviour of FOLDER.

Variable name	Description	Possible Values	Default

The following variables control the graphics and attributes of the display window and menu system.

DISPLAY	The X11 display id on which graphics will be drawn. If this is not defined (most systems initialise this to "**:0**") then no connection can be made to an X server, and no graphics will be drawn.	(<*machine name*>)**:*<server id>***(<*.screen id*>)	**:0**
DISPLAY_SATURATION DISPLAY_BRIGHTNESS DISPLAY_FACTOR	Saturation controls the colour saturation (intensity) of menus Brightness controls the colour brightness of menus "Factor" sets the relative display scale, and can range from 0.5 (making menus larger) to 2.0 (making them smaller). It may also be set to "**automatic**" which derives a factor from the physical screen dimensions.	0.0 to 1.0 0.0 to 1.0 0.5 to 2.0, or **automatic**	**1.0** **1.0** **1.0**
SM_USE_VISUAL	Sets the X11 "visual" id to be used for screen menus. Where a graphics display provides "overlay" planes these should normally be used, otherwise this should be left undefined or set to "default". Using an explicit visual id is possible, and this should be defined in hexadecimal (eg 0xf16). Experience has shown the on some Silicon Graphics systems using the "overlay" planes can result in very strange colours in other windows, in which case "default" should be used. Also on some W2000 and graphics board combinations problems may also arise with overlay planes and, again, "default" should be used.	**overlay** **default** <*visual id*> in hex	**overlay**
USE_PIXMAPS	Controls whether or not the menus use "pixmaps" (off-screen memory) to produce smooth scrolling. Turning this off (false) will save memory, and may help memory problems on a display that has only limited memory available for the X server, but will give slightly jerky window scrolling.	**true** or **false**	**true**
PRIMER_NO_PIXMAP **PRIMER_NO_PBUFFER**	May be used to suppress backing store redraws for the OpenGL graphics window. Should be used on OpenGL / X graphics combinations only if you receive errors starting "GLX ...", and then only after consultation with Oasys.	**true** or **false**	**false**
SAVE_UNDER	This flag was introduced to fix a specific bug on Compaq Alpha OSF4.x operating systems. Normally the window manager requests a redraw of windows that have been updated, even when they are currently obscured by something else. However the OSF4 window manager series failed to do this, leading to "bare" patches underneath popup menus when these were unmapped. Setting this flag to **false** results in more redraws on these systems since it suppresses the default "save under" property of X11 windows, but it does at least prevent windows getting bare areas. Compaq have fixed the bug in OSF5, and possibly in later releases of OSF4.	**true** or **false**	**true**

CP_FILE_FILTER	Used during checkpoint file replay to override any file and pathname stored in the checkpoint file, bringing up the file filter instead. This allows checkpoint files to be replayed on different systems.	**true** or **false**	**false**
The following controls the display of on-line manual pages on Unix systems only. (Windows systems use the default web browser.)			
NETSTART	Command string to start Netscape on Unix/Linux hosts. This is used to fire up the Netscape browser in order to read manual pages from within FOLDER.	Any valid Unix command string.	<*none*>
The following variables are provided for debugging purposes only, and should not normally be used.			
DB_POINTER_CHECK	Runs a check during every internal database allocation and return operation to scan for duplicated or erroneous pointers. This will result in very much (potentially 100x) slower operation of internal memory management, and is normally only used to track down internal errors.	**false**, **1** or **2** (Turned off, level #1 or level #2 checking)	**false**
XSYNC	Runs the X server in "synchronised" (unbuffered) mode. This will give woefully slow graphics, and is used for debugging purposes only.	**true** or **false**	**false**
WARN_REDEFINE	Makes the menu system issue a warning if a button is redefined. Again this is normally only used for debugging purposes.	**true** or **false**	**false**